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Level II Audit of Terephthalic Acid Smoke Grenade Manufacturing Process

Pine Bluff Arsenal, AR

by
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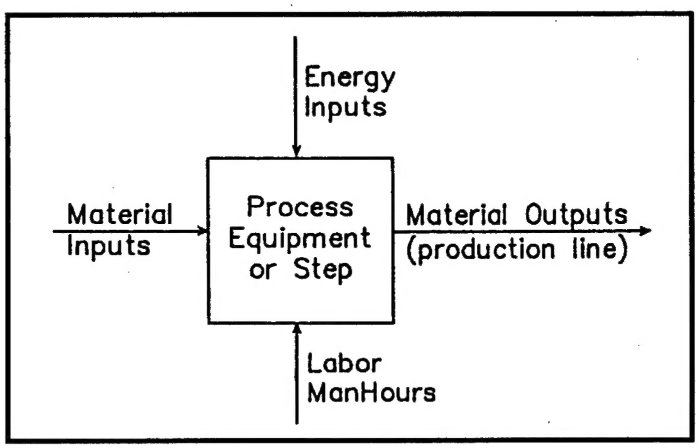

Meeting environmental requirements with the currently installed technologies is a problem common to the existing DOD industrial base. Compliance with environmental law is becoming significantly expensive for Army installations. This study was undertaken to provide Army installations with methods to meet pollution regulations by reducing the formation of waste, including stack gas, from energy production. An understanding of the energy-use patterns and options in the production sites, combined with innovative and effective methodologies, can help identify energy and emission reduction opportunities.

In 1996, the U.S. Army Construction Engineering Research Laboratories (USACERL) sponsored a 3-day Level I Process Energy Review and Process Energy and Pollution Reduction workshop at Pine Bluff Arsenal, AK. The specific area defined for the process improvement and energy reduction activities was the terephthalic acid (TA) smoke grenade process. The review and workshop provided training to site technical personnel to analyze existing manufacturing processes, and to identify process changes that improve energy efficiency, raw material use, plant capacity, product quality, and environmental advantages. This study performed a Level II audit of TA smoke manufacturing to optimize capacity and energy, and environmental performance of that process.

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Meeting environmental requirements with the currently installed technologies is a problem common to the existing DOD industrial base. Compliance with environmental law is becoming significantly expensive for Army installations. This study was undertaken to provide Army installations with methods to meet pollution regulations by reducing the formation of waste, including stack gas, from energy production. An understanding of the energy-use patterns and options in the production sites, combined with innovative and effective methodologies, can help identify energy and emission reduction opportunities.

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Foreword

This study was conducted for Pine Bluff Arsenal Office of Environmental Management and the Office of the Deputy Undersecretary of Defense for Environmental Security, conservation, and Installations under Military Interdepartmental Purchase Request (MIPR) No. FJ6 V6048 FJ; Work Unit FJ6, "Level II PEPR Audit at Pine Bluff Arsenal, AK." The technical monitor was Phillip Vick, SMCPB-EM.

The work was performed by the Industrial Operations Division (UL-I) of the Utilities and Industrial Operations Laboratory (UL), U.S. Army Construction Engineering Research Laboratories (USACERL). Consulting support for this study was provided by ETSI Consulting and Stanley Consultants, Inc. The USACERL principal investigator was Jearldine I. Northrup. Walter J. Mikucki is Chief, CECER-UL-I; John T. Bandy is Operations Chief, CECER-UL; and Gary W. Schanche is the associated Technical Director, CECER-UL. The USACERL technical editor was William J. Wolfe, Technical Resources.

COL James A. Walter is Commander and Dr. Michael J. O'Connor is Director of USACERL.

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1 Introduction

Background

Defense Energy Program Policy Memorandum (DEPPM) 91-2 and Executive Order 12759 assigned energy efficiency goals for Federal facilities for fiscal year 2000 (FY00) as compared to the FY85 base year. Each Department of Defense (DOD) component is directed to prescribe policies and establish appropriate measures of energy efficiency under which the aggregate of its industrial energy-consuming facilities will increase energy efficiency by at least 20 percent in FY00 in comparison to FY85. Executive Order 12902 calls for an increased energy efficiency in Federal industrial facilities by at least 20 percent by FY05 compared to FY90 and requires agencies to implement all cost-effective water conservation projects. The Order also increases the energy savings requirement for agencies to 30 percent by FY05 compared to FY85 in British thermal units (Btu) per gross square foot.

Executive Order 12856 requires the Army to reduce the use of energy and related environmental impacts by promoting renewable energy technologies. Section 3-302 (a) requires a 50 percent reduction in toxic chemical and pollutant releases to the environment by 31 December 1999. Executive Order 12873 requires the Army to incorporate waste prevention and recycling in everyday operations and to acquire and use "environmental preferable" products and services to the maximum extent practicable. Beginning 4 April 1994, Section 503 requires periodic modification to procurement guidelines to incorporate latest USEPA guidance.

These energy and environmental directives usually exceed the performance capabilities of DOD's currently installed industrial technologies. While future DOD industrial facilities will employ state-of-the-art production technologies being developed jointly by the Army's ManTech program and Department of Energy's (DOE's) Sandia National Laboratory, the majority of DOD industrial activities use technologies and facilities that are at least 40 years old. Meeting environmental requirements with the currently installed technologies is a problem common to the existing DOD industrial base. Compliance with environmental law is becoming a significantly expensive proposition for Army installations.

In the past, pollution prevention was considered independently from compliance. Environmental law was introduced to persuade managers of pollution-producing industrial processes to seek ways to change production methods to lessen pollution. The hierarchy setup by the U.S. Environmental Protection Agency (USEPA) pollution prevention opportunities (PPOs) is based on the principles of

source reduction, conservation of materials and energy, recycling, and substitution of nonhazardous materials for hazardous materials. Many research installations, including the U.S. Army Construction Engineering Research Laboratories (USACERL) have documented and compiled energy conservation opportunities (ECOs) common in manufacturing.

For example, energy use is a significant problem in air compliance. Most criteria air pollutants are produced by industrial boilers and electric power plants. However, environmental engineers are oftentimes not trained to think in terms of the supply side of energy production and process improvement to reduce pollution. Therefore, they tend to seek "tail pipe" solutions to air compliance problems. Such solutions require even more energy and are often expensive to maintain. These energy costs are only a small fraction of the societal cost of stack gas. Health problems of persons living in the waste stream path, acid rain, destruction of forests, and loss of wild life are rarely taken into account.

This study was undertaken to provide Army installations with methods to meet pollution regulations by preventing pollution—by reducing the formation of waste, including stack gas from energy production. In the optimal pollution-prevention situation, all raw materials brought to the manufacturing facility leave as product. If there is waste in the air, water, or in solid form, the producers of that waste should attempt to dispose of it to another manufacturer who can reprocess it into a usable commodity. Most states now have a material exchange set up in which one manufacturer can use the scraps from another. This approach requires specific areas where cost-effective compliance with directives is mandated to undergo a thorough evaluation of industrial activities for potential improvements. An understanding of the energy-use patterns and options in the production sites, combined with innovative and effective methodologies can help identify energy and emission reduction opportunities.

In 1996 USACERL, under the Federal Energy Management Program (FEMP), sponsored a 3-day Level I Process Energy Review and Process Energy and Pollution Reduction workshop at Pine Bluff Arsenal (PBA), Pine Bluff, AK. The specific area defined for the process improvement and energy reduction activities was the terephthalic acid (TA) smoke grenade process. The objective was to optimize manufacturing cost at lower levels with improved quality, raw material utilization, and environmental and energy performance by modification of process operations or technology. The review and workshop conducted at PBA provided training to site technical personnel to enable them to analyze existing manufacturing processes, identify process changes that improve energy efficiency, raw material utilization, plant capacity, product quality, and environmental advantages. Following the Level I Audit on the TA smoke grenades, USACERL received a request from PBA to perform a Level II audit of the TA Smoke manufacturing process.

Objective

The objective of the project was to conduct a Level II audit on the TA smoke grenade process for the Industrial Process Improvement Program at PBA to optimize capacity and energy and environmental performance. The Level II audit was conducted by USACERL researchers and PBA technical staff.

Approach

PBA provided USACERL with Production Division Monthly Labor Yield reports (Appendix A). Job #AB033/4208C (M83 smoke grenades) was selected for analysis. The time period for this job was from February 1996 to 31 May 1996. The data from the PBA report were entered into a spreadsheet to more easily allow data elements to be sorted into their respective activity codes.

PBA technical staff and USACERL researchers reviewed the information gathered during the Level I audit of the TA smoke grenade process and conducted a Data-Gap Analysis to determine whether additional data were required for the Level II audit.

The USACERL team visited PBA in August 1996, and with PBA technical staff, collected information on the selected ideas from the Level I audit. This work included analysis of readiness (startup time, capacity, etc.); reliability (power outages, etc.); quality (correct measurements, corrective actions, etc.); safety and health, environmental issues, utilities, labor requirements, and cost.

This task produced documentation for the work performed at PBA for the project. Documentation included a summary report highlighting the low investment and high payback project areas and DOD investments needed to reduce industrial energy. Information was incorporated into a software format that was already written, thereby giving a baseline for further work at the installation by installation personnel.

Scope

This Level II audit reviewed industrial processes at Pine Bluff Arsenal, AK. Although the conceptual results of this study may have broader application to processes across the DOD industrial base, specific conclusions and recommendations of this study relate solely to this site.

Mode of Technology Transfer

It is anticipated that the general conceptual results of this work will be incorporated into the Process Energy and Pollution Reduction (PEPR) computer software program, the primary purpose of which is to provide users with a flexible analysis tool for rapidly evaluating process energy and pollution reduction opportunities for industrial processes at DOD facilities. PEPR is an

ongoing research effort that will assist DOD industrial facility managers in making informed decisions on process energy reduction and pollution prevention.

Specific data derived from this study will be transferred to the Pine Bluff Office of Environmental Management at Pine Bluff Arsenal, AK, to be further distributed only as directed by that office or higher authority.

Metric Conversion Factors

The following metric conversion factors are provided for standard units of measure used throughout this report:

1 in.	=	25.4 mm
1 ft	=	0.305 m
1 sq ft	=	0.093 m2
1 mi	=	1.61 km
1 lb	=	0.453 kg
1 gal	=	3.78 L
1 psi	=	6.89 kPa
1 ft-lb	=	1.356 joules
1 ton	=	0.907 metric ton
1 acre	=	0.40469 ha

2 Current TA Smoke Grenade Process

TA Smoke Grenade Process Overview

PBA has the ability to mix, fill, load, assemble, and package a wide variety of smoke munitions. These include colored smoke, irritants, thickened pyrophoric agent (TPA), hexachlorethane (HC) smoke, and terephthalic acid (TA) smoke grenades, the subject of this report. TA is produced by converting mixed xylenes to paraxylene and combining a feed mixture of paraxylene, catalyst, and acetic acid with air in a continuous reactor. The paraxylene is oxidized to produce crude TA, which then is purified through catalytic hydrogenation and crystallization. The resulting white powder is >99.96 percent pure. The TA is purchased from a commercial manufacturer in 1000-kg supersacks. A review of the current TA smoke grenade process follows.

The manufacturing process of TA smoke grenades is conducted in three separate operations each performed at a separate facility to comply with safety regulations. The three lines involved in TA smoke grenade production are: Glatt mixing line, fill and press line, and load and packout line.

The Glatt Mixing Line

The steps involved in the Glatt line are conducted in building 32-620. Seven persons are involved in the Glatt mixing line. A description of each of the Glatt mixing steps follows, and Figure 1 shows a block process flow diagram of the Glatt mixing.

Step 1. Raw materials are received. The inputs and outputs of this step are TA, magnesium carbonate, potassium chlorate, sugar, and stearic acid.

Step 2. The 3 percent polyvinyl alcohol (PVA) binder is manufactured. The input is PVA, and the 3 percent PVA binder is the output.

Step 3. The raw materials are stored. Inputs and outputs are raw materials from Step 1 and PVA binder from Step 2.

Step 4. The raw materials are measured and mixed together. The potassium chlorate and sugar are sifted. The inputs are all of the raw materials from Step 3. The outputs are the raw materials combined into a mixture. The PVA binder is not mixed with the other components during this stage.

Step 5. The components (TA 57 wt%, $MgClO_3$ 4.2 wt%, $KClO_3$ 23.5 wt%, and sugar 14 wt%) are weighed and mixed. The inputs and outputs are the preceding components.

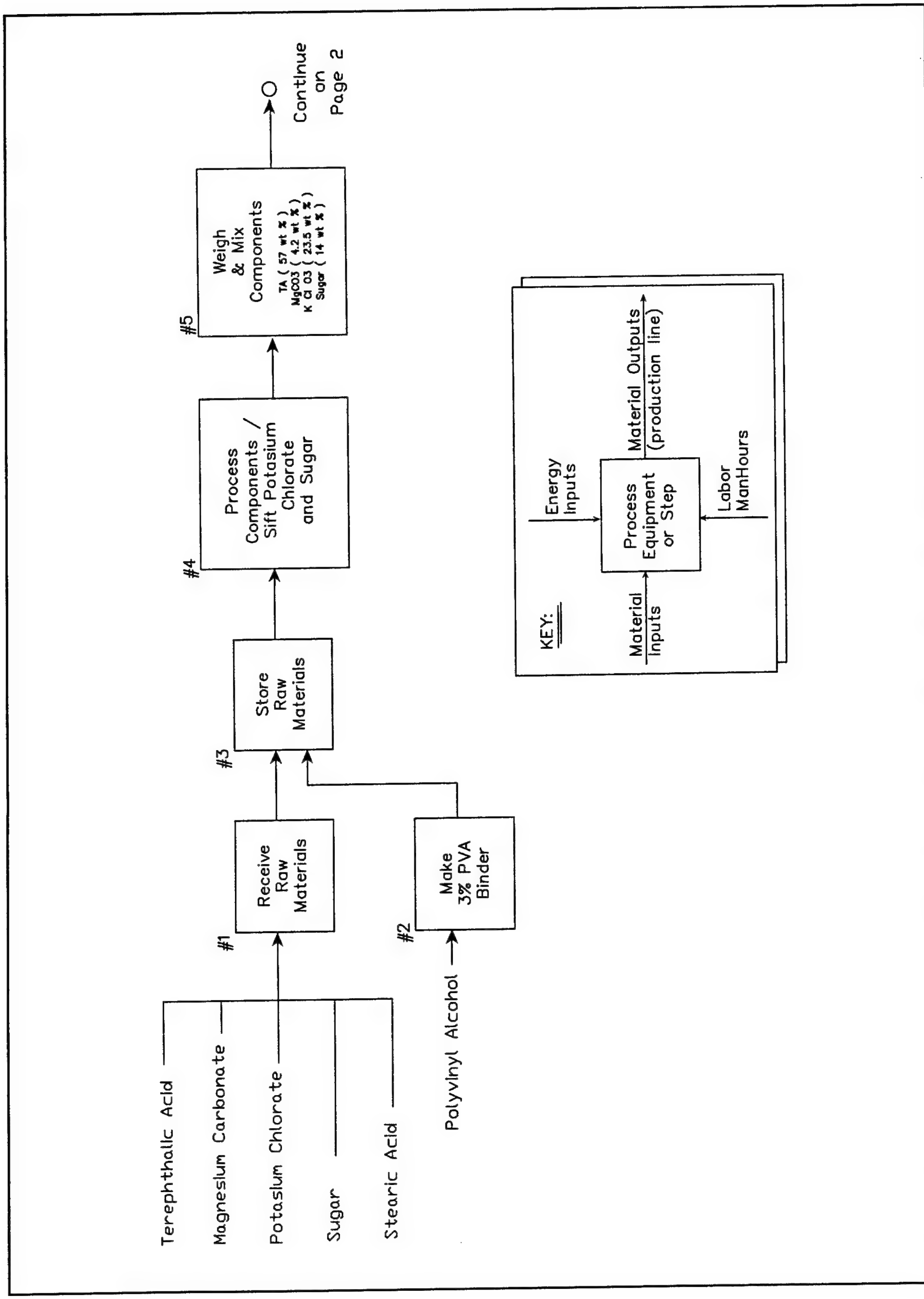
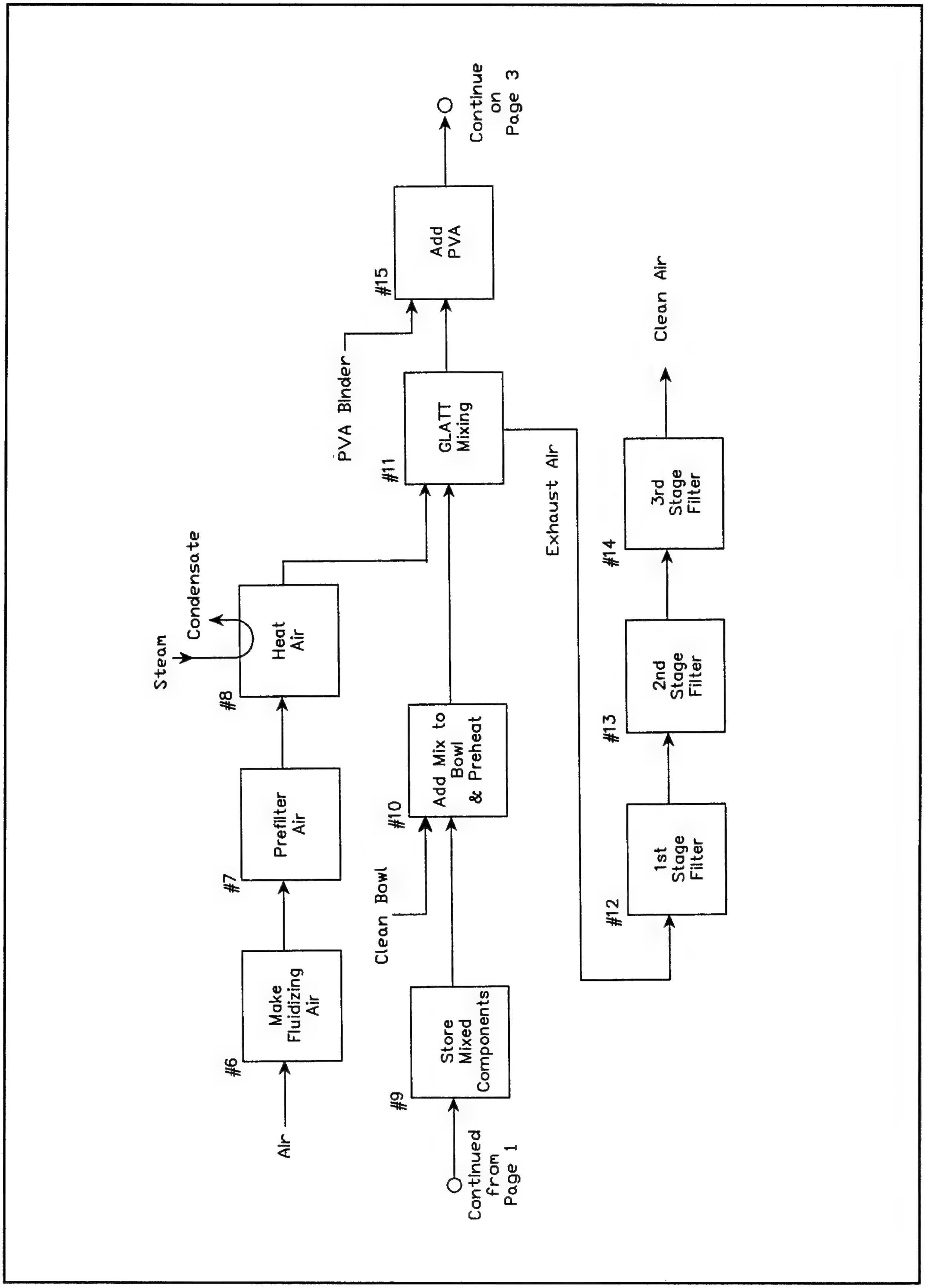


Figure 1. Block process flow diagram for Glatt mixing operation.



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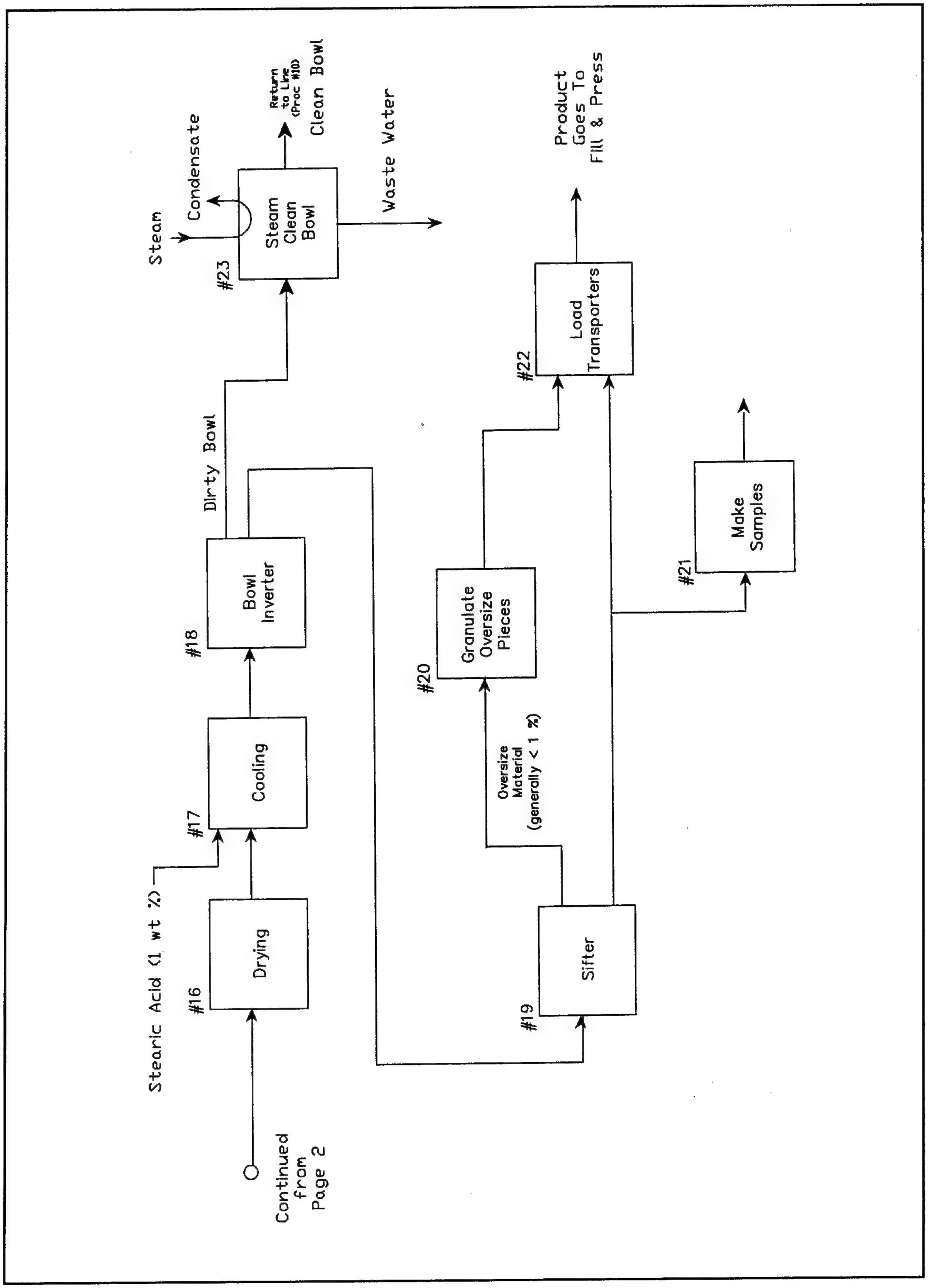


Figure 1. (Cont'd).

Step 6. Make fluidizing air. The input is air, and the output is fluidized air.

Step 7. The fluidized air is prefiltered. The input is fluidized air, and the output is prefiltered fluidized air.

Step 8. The prefiltered air is input and steam is input to heat the air, using steam coils. The heated air is output and condensate is removed.

Step 9. The output components from Step 5 are input and stored.

Step 10. The stored, mixed components from Step 9 are input into the mixing bowl and heated for 20 minutes.

Step 11. The mixing bowl containing the components from Step 10 is placed in the Glatt mixer. The mixer is raised into position, and the main turbine is started. In addition, the heated air from Step 8 is input. The output is the mixture of components and the exhaust air. The Glatt mixer uses a fluidized bed process to agitate and granulate the mix components. Throughout all of the mixing stages, the air flow is stopped while the sock filter is shaken to clear it of accumulated dust and to reduce the pressure drop across the filter itself. The objective is to obtain uniform granule size.

Steps 12, 13, and 14. These steps are first stage filter, second stage filter, and third stage filter, respectively. The exhaust air from Step 11 is fed into Step 12, and then the air goes through each filter in turn to remove impurities. "Clean" air emerges from the third stage filter (Step 14). This air is free from any particles from the process mixture.

Step 15. The Glatt mixture is input and the PVA binder is added. The output is the combined mixture.

Step 16. This is the drying stage at which the binder solvent is removed by evaporation. The duration of the drying process partially depends on the temperature of the mix, but it is approximately 40 minutes.

Step 17. The mixture from Step 16 is cooled and stearic acid 1 wt% is added. The stearic acid in powder form is introduced into the mix with only a few minutes remaining in the cooling cycle. The cooling cycle is approximately 10 minutes.

Step 18. After completion of the mixing stage, the bowl containing the product is removed from the mixer and transported to the bowl inverter, which raises the bowl and inverts it. The dirty bowl is removed and the components are output to the sifter.

Step 19. The sifter receives the dried and cooled components from the preceding steps. Oversize granules are separated from the correct-sized granules.

Step 20. The oversize granules that were separated from the mixture (usually less than 1 percent) are reprocessed.

Step 21. Some of the sifted material is drawn off for sampling. This is a quality control step.

Step 22. The regranulated oversized particles and the sifted material from Step 19 are received and loaded into transporters to go to fill and press.

Fill and Press Line

The second part of the TA smoke grenade process is conducted in building 33-530. A total crew of 28 persons works on this line. Figure 2 shows the steps of the fill and press described here:

Step 1. The previously mixed and sifted materials from the Glatt process arrive in transporters.

Step 2. The supply materials are loaded into the hopper.

Step 3. Slugs are pressed.

Step 4. Cans and slugs are input, and the slugs are loaded into the cans.

Step 5. Ten cans at a time with slugs move into the consolidate press (Bottleneck #3).

Step 6. Sets of four move into the vacuum station where excess is removed.

Step 7. Sets of four move into the manual station and screen is also input. The screen is inserted into each can.

Step 8. The screen is pressed into place

Step 9. The height of fill and screen is checked.

Step 10. Pick and place; cans are picked up and placed on a conveyor belt.

Steps 11 and 12. These two steps, in addition to Steps 13 and 14, are conducted on the fast conveyor belt and constitute Bottleneck #1. The two steps comprise the installation of a plastic cup and starter cap, and an auto check.

Step 13 and Step 14. Discs are loaded into the cans in Step 13. An auto check is performed on the output. Step 14 is pick and place.

Step 15. The lid is installed and the can is sealed (Bottleneck #2). The can lids are the input and the sealed cans are the output.

Step 16. The residue is cleaned off the exterior of each can.

Step 17. Check station conveyor.

Step 18. The can is taped.

Step 19. The can is painted two colors.

Step 20. The paint is dried.

Step 21. White markings are applied.

Step 22. A blue band is applied.

Step 23. The fuse is introduced and twisted.

Step 24. The fuse is torqued.

Step 25. The containers are fed onto the line and separated.

Step 26. Each filled canister (unit) is placed into a container.

Step 27. A protecting collar is installed over the fuse.

Step 28. Close fiber container.

Step 29. Put in box. The small box* has dimensions of 18 x18 in. and holds 16 canisters.

Step 30. Put the box on a pallet.

Step 31. The pallets are sent to storage.

Typically, four batches of 1,200 lb of mixture are received at the Fill and Press Line and 5,500 units per day are produced, each unit containing 0.218 lb.

Load and Packout Line

Load and Packout is conducted in building 33-570, which includes an area of 30,000 sq ft. There are 98, 1 x 4-ft fluorescent lamps in the building. Fourteen persons are required to conduct the operations of this line, and the daily capacity is 10,000 units. Figure 3 shows the steps associated with the load and packout line described here:

Step 1. The cans are manually removed from the boxes in which they are received from the fill and press lines and are loaded onto both sides of a conveyor belt. There is one pneumatic motor for the load conveyor, which is run at approximately half speed to feed the tape and stencil machines. The conveyor is capable of running more than 20,000 grenades per day.

Steps 2 and 3. The cans are conveyed to the tape and stencil machine. A bottleneck could be created coming out of the tape and stencil machine because the grenades must be 100 percent inspected. Two machines will keep two inspectors busy constantly. The boxes are hand stenciled. An automatic box stenciling machine has been tried in the past. Because of irregularities in the boxes (size not uniform, box sides made of more than one board, etc.) the machine did not work. Two persons stenciling the boxes can keep the box loader full.

When small boxes are not available, large boxes (capacity 360 canisters per box) are used. The small boxes are manufactured by an organization employing disabled persons and sometimes the boxes are not available.

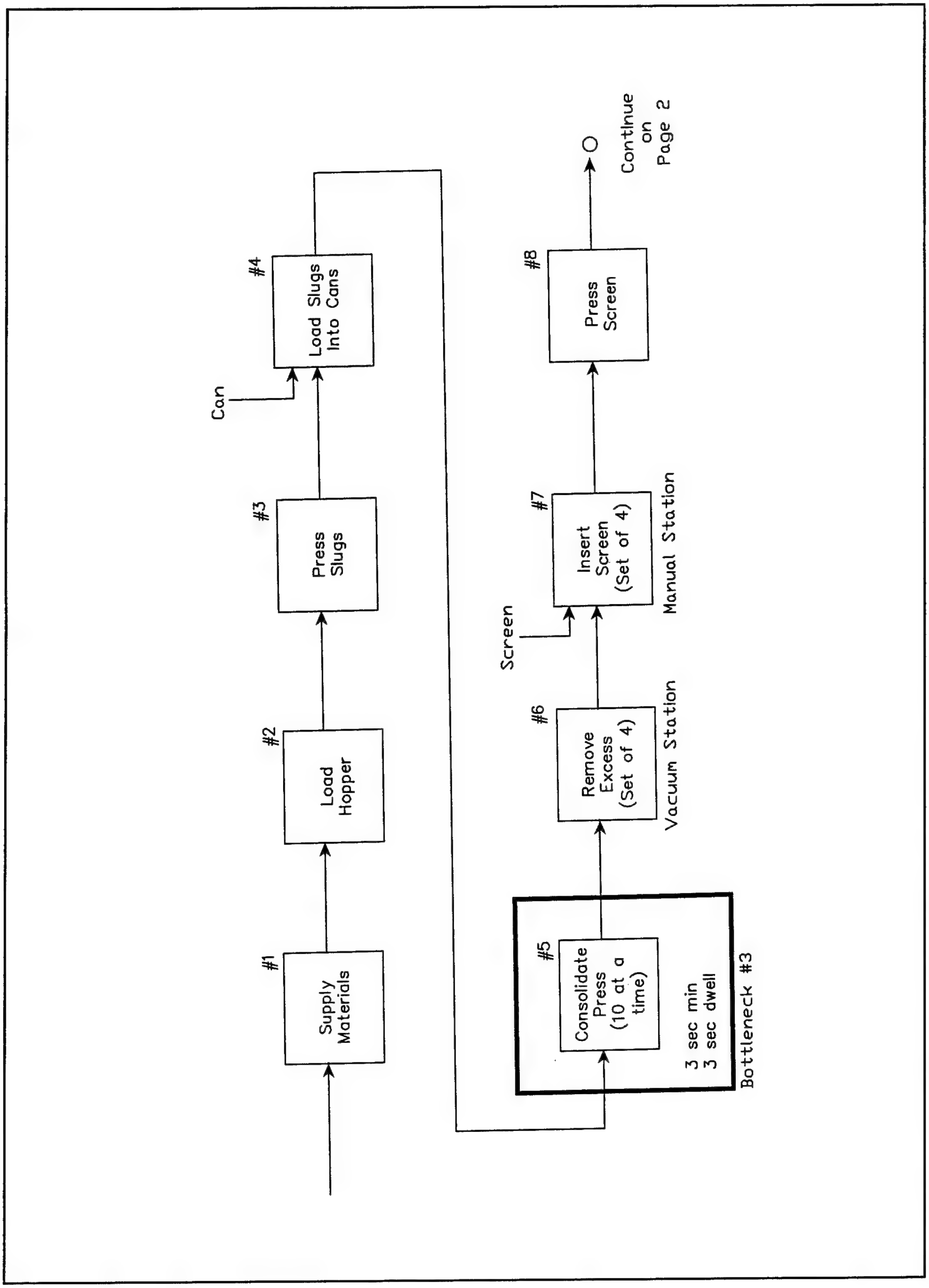
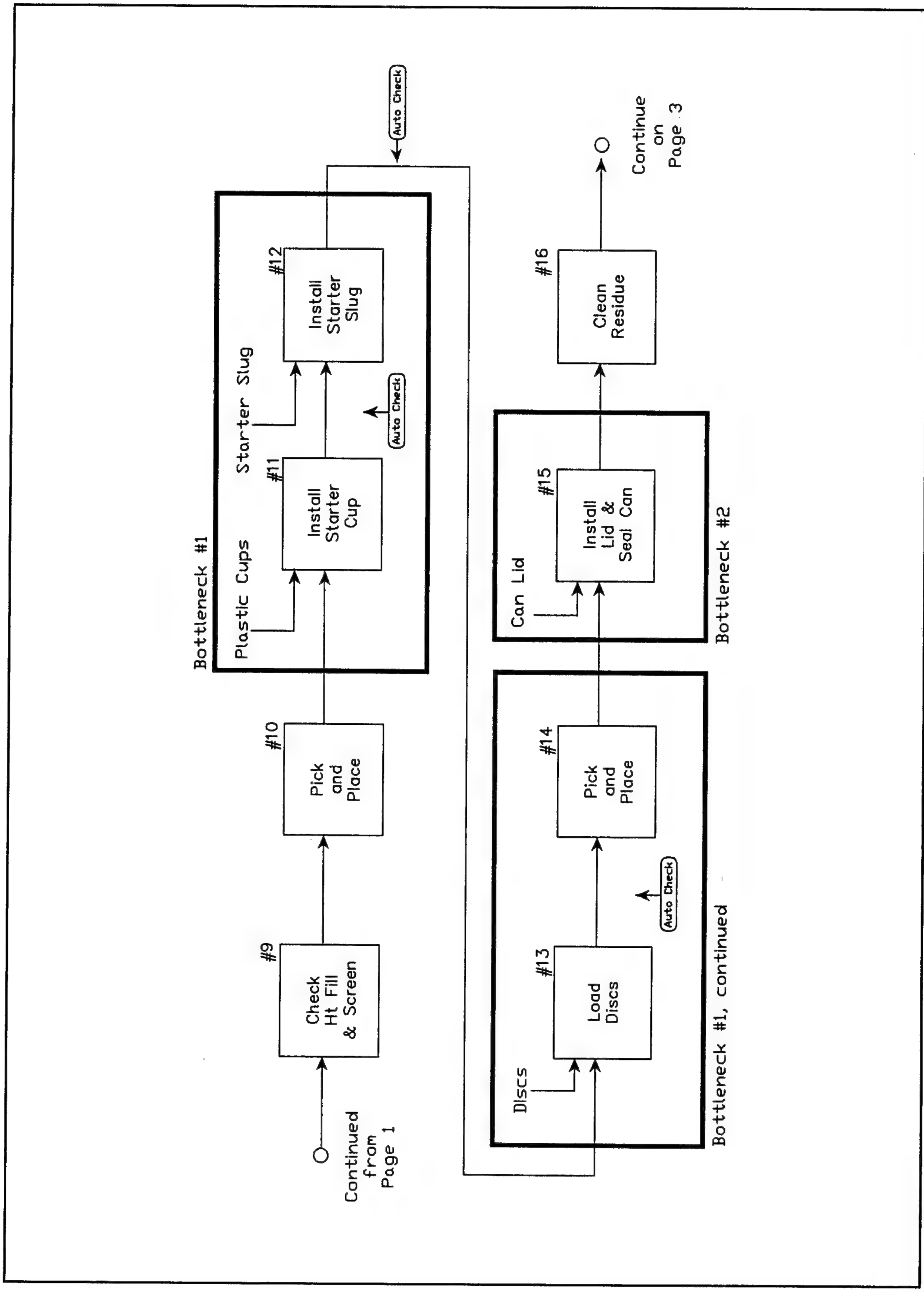


Figure 2. Block process flow diagram for fill and press operation.



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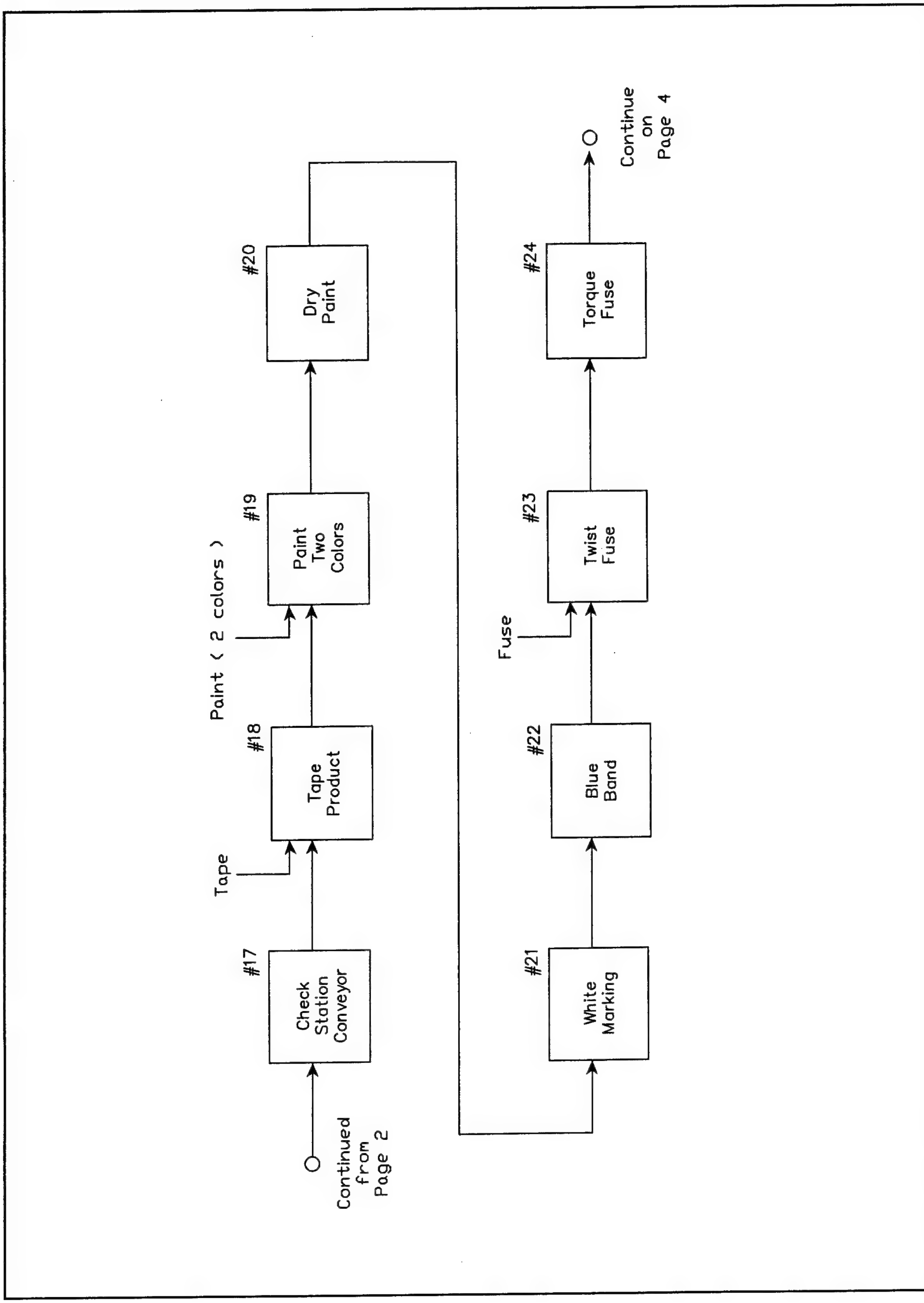

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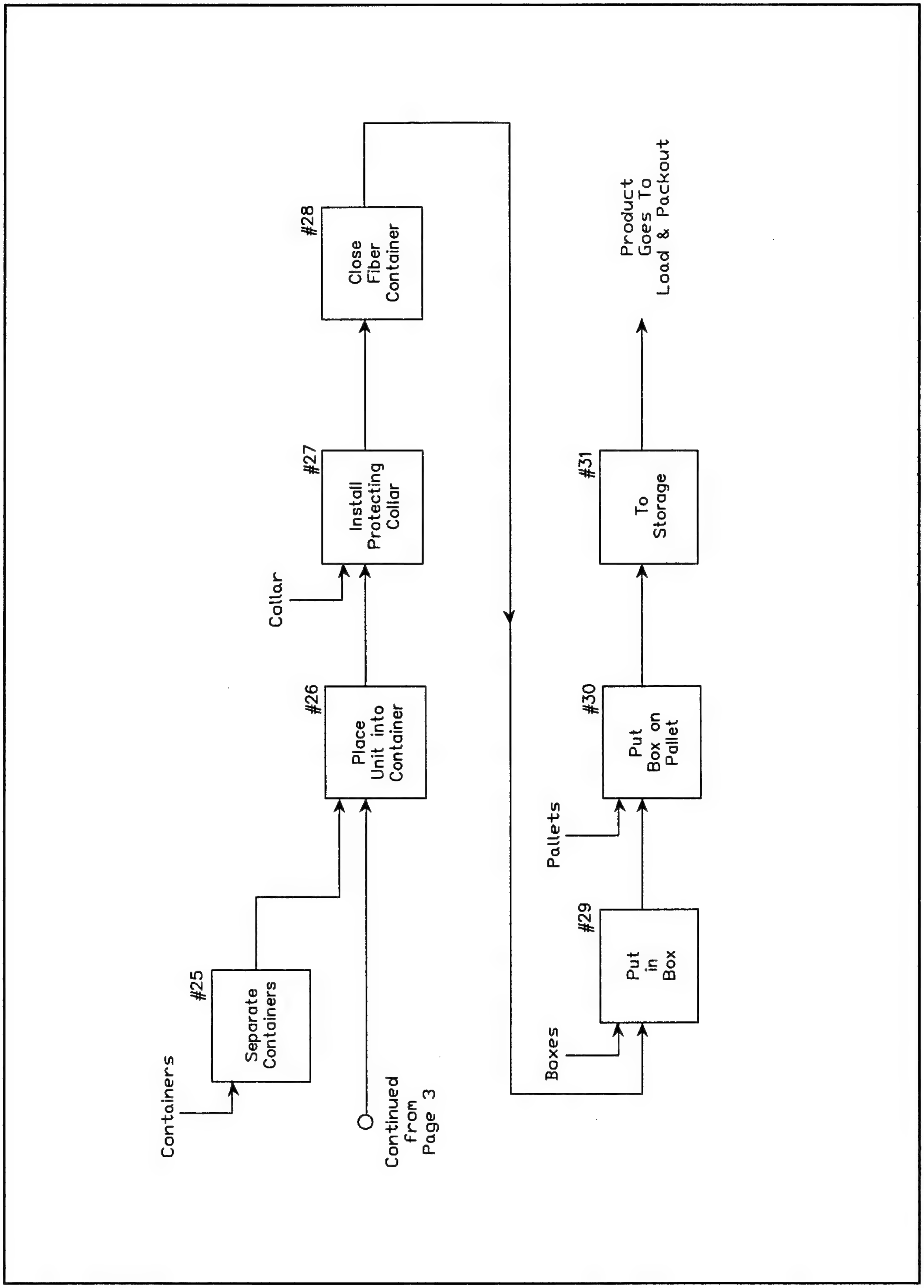

Figure 2 (Cont'd).

Step 4. After the canisters are taped and stenciled, they are conveyed to the accumulator. The box loading machine can keep pace with the operator putting the packing material into the boxes.

Step 5. The cans are inspected for paint touch-up. Only about 5 percent need rework at this stage. Those 5 percent are sent to Step 6; the other 95 percent proceed directly to Step 8 (load crate). One operator is responsible for both steps 5 and 6.

Step 6. The 5 percent rejects are conveyed to the rework area. The canisters are repainted at the rework booth and immediately put back on the line.

Step 7. Wooden crates are prepared.

Step 8. The crates are loaded. The cans continue on the conveyor to the load box area.

Step 9. Grenades are packed into wooden boxes along with overpack material. The packing consists of two different types of material.

Step 10. Operating instructions are added to each box.

Step 11. The boxes are conveyed to a semiautomatic machine that nails the lids in place. The box lid is not a single piece of wood; it usually is two pieces of wood connected with a corrugated nail.

Step 12. The boxes are moved to the automatic wire tie machine. The box is wired in two places.

Step 13. The boxes are palletized. One operator uses a forklift truck to put empty pallets in the palletizing machine and to remove the full pallets as the machine dispenses them.

Step 14. The same operator who does Step 13 straps the full pallets.

Step 15. The boxes are stored in local storage until the consignment is completed. The operator who does Step 13 removes the full pallets to the storage building across the road. This operator also brings the grenades from the storage building to be loaded onto the conveyor in Step 1.

Step 16. When the consignment is complete, it is shipped to North End Storage until it is shipped to the customers.

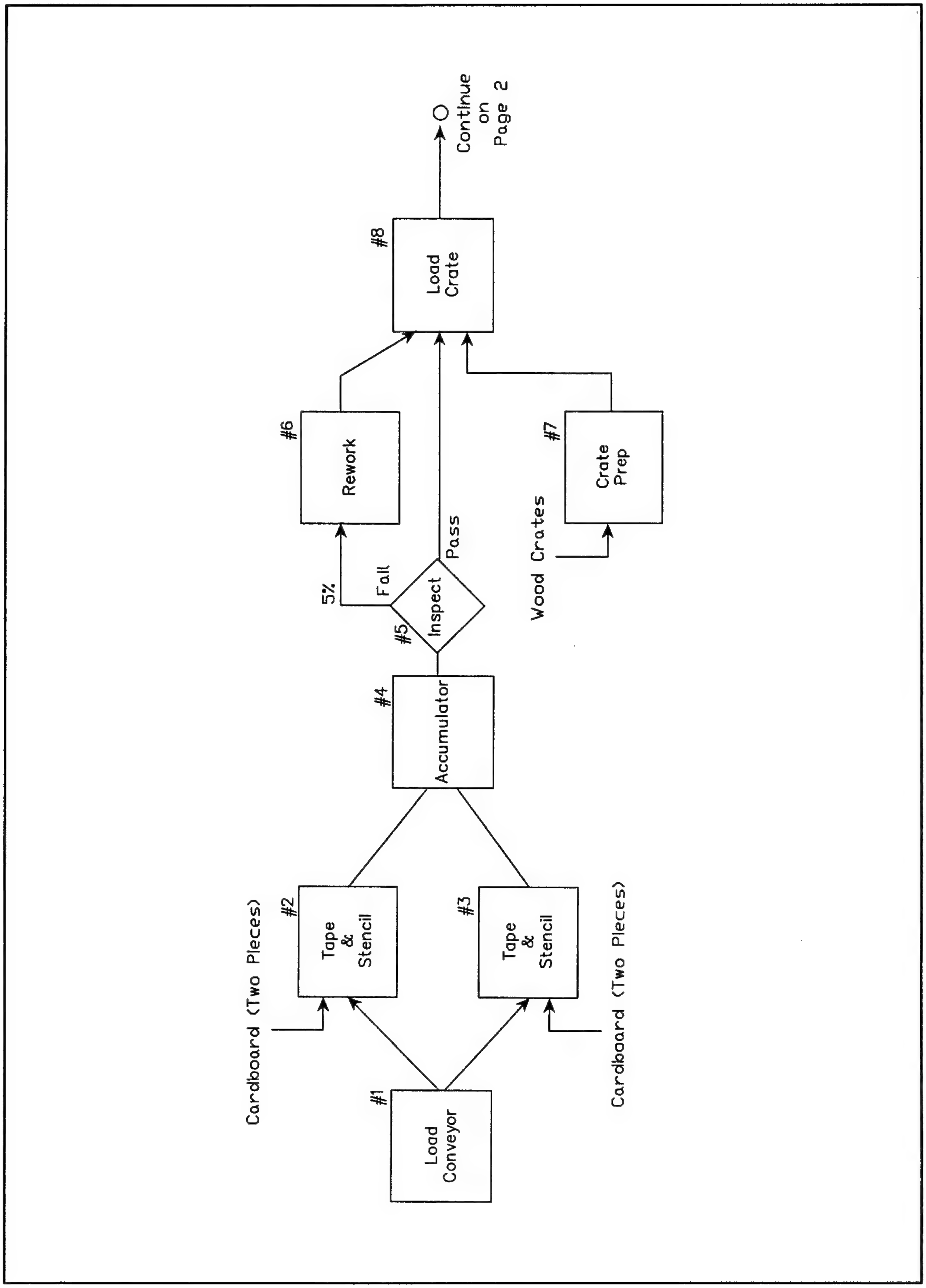

Figure 3. Block process flow diagram for load and packout operation.

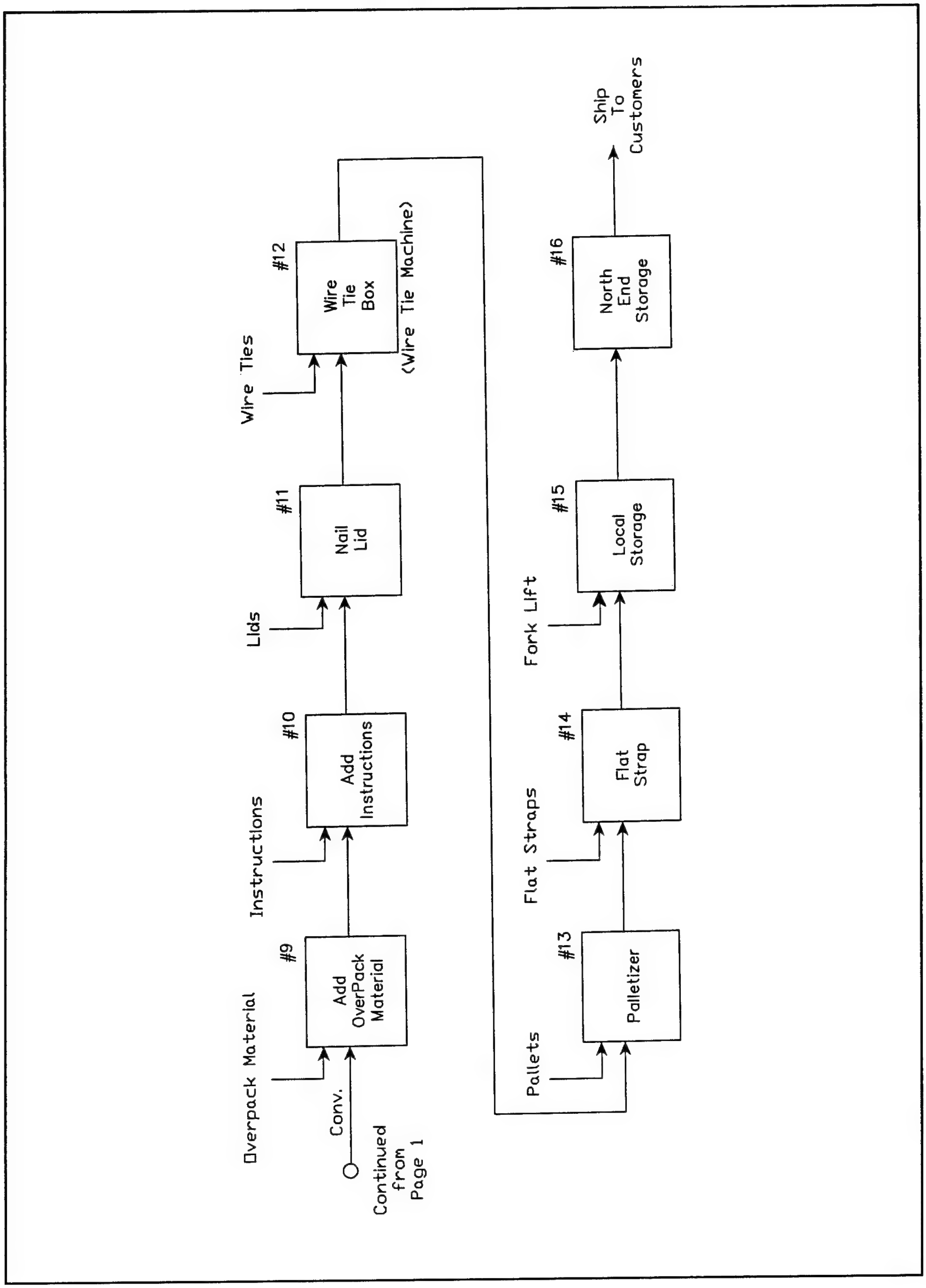

Figure 3. (Cont'd).

3 Optimization of TA Smoke Grenade Process

A Process Data-Gap Analysis was conducted prior to the Level II audit on the TA smoke grenade process. This analysis involved a review of the data gathered during the Level I audit. The data and associated material were provided by PBA technical staff, USACERL researchers, and contractors during brainstorming sessions. The following types of collected-data included: operational (standing operating procedures, technical, raw materials), quality (specifications, measurements), maintenance (requirements, frequencies), utilities usage, pollutants (air, water, solid waste), and cost. The results of the brainstorming sessions are included in Tables A3, A4, and A5 in Appendix B to this report.

USACERL researchers reviewed the information and analyzed each selected item for capacity, environment, and energy. Determinations were made on: (1) how much useful data had been acquired, (2) additional data that needed to be developed and/or compiled, and (3) nonvalue-added information that could be eliminated. General and specific questions were asked to ascertain where data were missing or, in some cases, redundant. Missing data elements were supplied by PBA technical staff (see Appendix C for Data-Gap Analysis questions).

Level II Audit on TA Smoke Grenade Process

A Level II audit is an aggregated or holistic notion, unlike a Level I audit in which each aspect is examined in its various components (capacity, environment, and energy). In the Level I audit of the TA smoke grenade manufacturing process, participants in the audit considered capacity, environment, and energy issues as separate entities. Each component was brainstormed, and the best ideas were selected and analyzed in terms of savings per year that the idea would produce if introduced, capital costs to implement the idea, and payback time. In the Level I audit, an economic analysis of the selected ideas was conducted, but no measurements were taken. PBA technical experts guessed at costs of implementing ideas and their associated cost-benefits.

In the Level II audit, USACERL researchers conducted a combined assessment of the Level I results. The objective was to identify and evaluate opportunities to reduce process-related waste, conserve process-related energy, and optimize process capacity. Process-related wastes include hazardous and nonhazardous waste in the forms of air emissions, liquid wastes, and solid wastes. Process-

related energy includes equipment operation and maintenance, steam generation and utilization, compressed air generation and utilization, space heating and cooling, lighting, and transportation.

Data From PBA

From the Summary Scrap-Rework Cost Monthly Report, information regarding the 1996 order for M83 training grenade scrap data was analyzed. This summary states that $7,499 was spent for scrap in May, $7,218 in April, $10,155 in March, and $2,977 in February. The total scrap amount for the M83 training grenade production was $27,849. Total units completed were 38,432 for May, 38,096 for April, 81,120 for March, and 75,664 for February—a total of 233,312 units. Net value is the number of units produced multiplied by the cost of the end item, including direct labor rate, administration rate, support rate, and direct materials and components. In this report, "other" refers to loss or damage of direct materials or components due to the vendor, manufacturer, or in transportation. Cost is determined in the same way for both scrap and rework.

From the Level I audit, the number of production hours estimated to produce 233,312 units of TA smoke grenades was 630 hours. The projected workhours for the job are calculated by multiplying the production hours by the number of personnel involved (31 workers x 630 hours = 19,530 workhours). From the Production Division Monthly Labor Yield for PBA, Job #AB033/4208C was selected for analysis of reported hours. Because USACERL did not have access to the computer system at PBA, the data for Job #AB033/4208C were put into a spreadsheet and sorted by activity code. (See Appendix A for spreadsheets.)

Figure 4 shows the breakdown of labor hours for Job #AB033/4208C. The reported net hours measured (16,355 hours, or 37 percent of the total labor hours) represents the actual workhours spent on manufacturing the TA smoke grenades. The remaining 63 percent of the total labor hours includes overhead hours (6,716.5 hours or 16 percent), leave hours (4,686 hours, or 11 percent), down hours (5,073 hours, or 12 percent), and hours unmeasured (10,299 hours, or 24 percent). measured hours are the hours recorded by a time clock and unmeasured hours are those hours that constitute the balance of an 80-hour pay period.

Figure 5 shows that actual hours measured (21,428 hours) constitute 68 percent of the aggregate of the measured and unmeasured hours. Figure 6 shows actual hours measured (21,428 hours) amounted to 67 percent of the combined total of actual measured hours, supervision hours (15 percent of the total), and other unmeasured hours (18 percent of the total). Line maintenance hours (231 hours) are only 2 percent of the total of other unmeasured hours (10,299), as Figure 7 shows. Figure 8 shows that rework (333 hours) is 2 percent of the actual measured hours (21,428 hours), and Figure 9 indicates that sick leave (1,656 hours) is 7 percent of the actual measured hours (21,428 hours). Figure 10 shows a breakdown of the unmeasured hours. Figure 11 shows the results of a survey of U.S. industries (Read, pp 18-23).

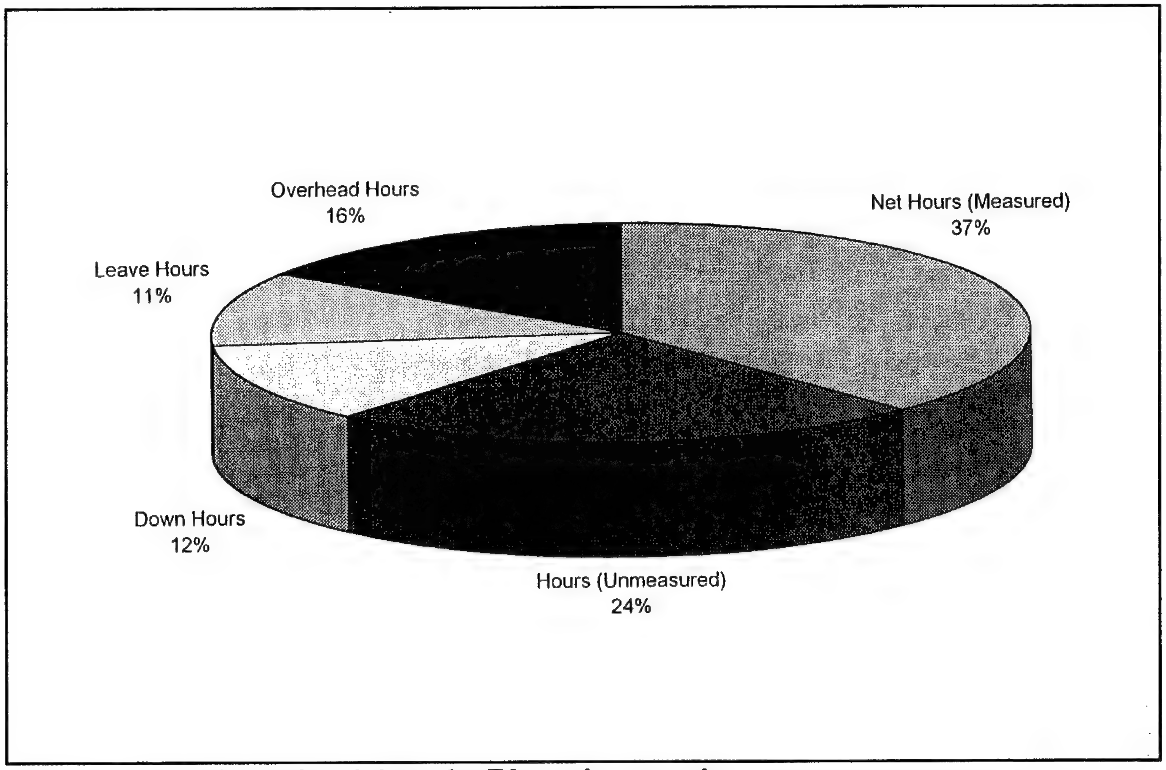

Figure 4. Labor hours breakdown for TA smoke grenade.

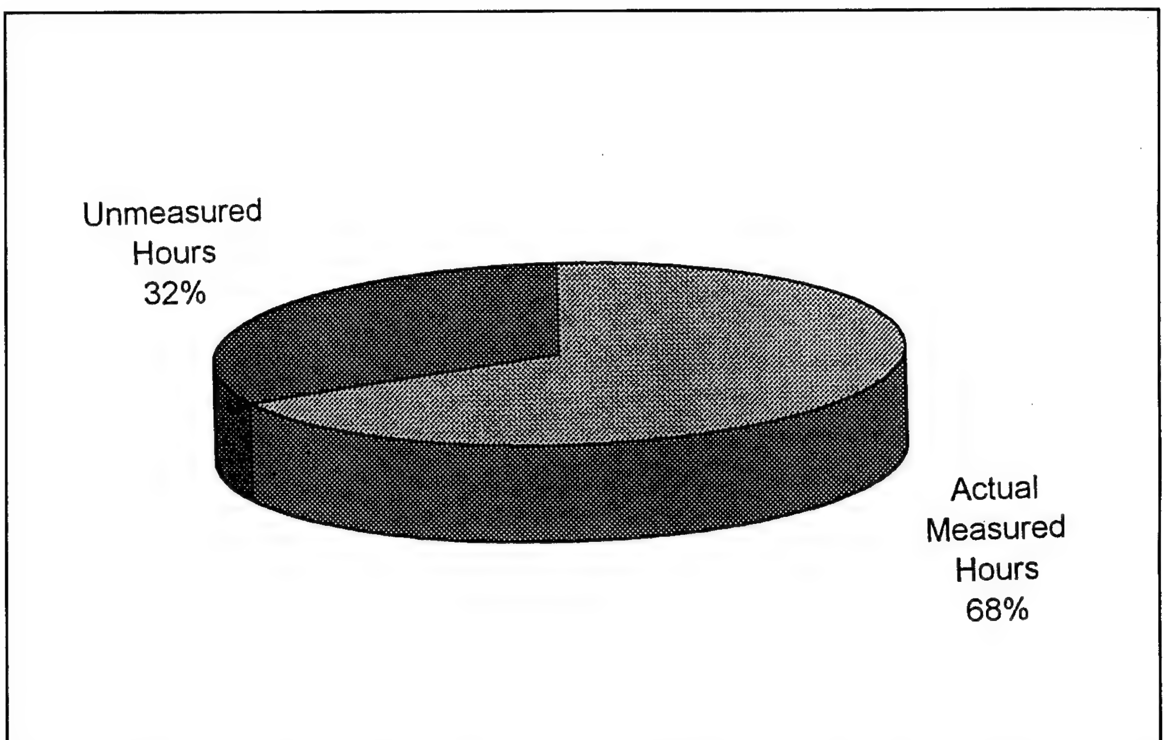

Figure 5. Measured hours vs. unmeasured hours.

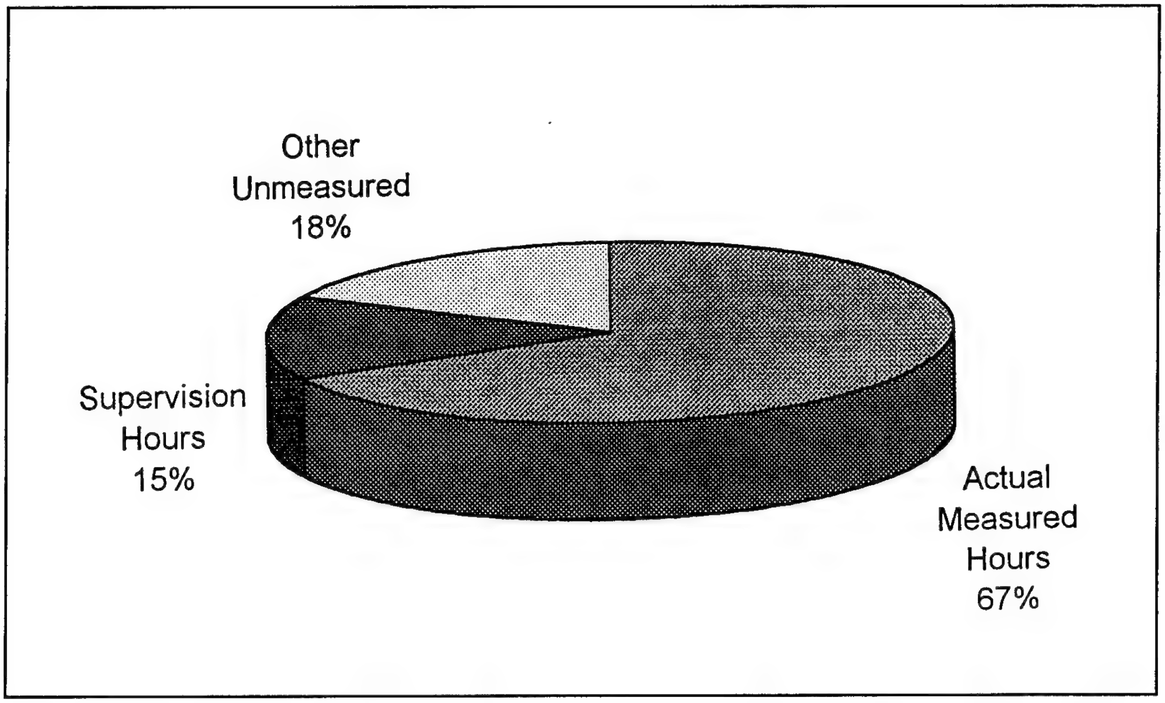

Figure 6. Measured labor hours vs. supervision hours.

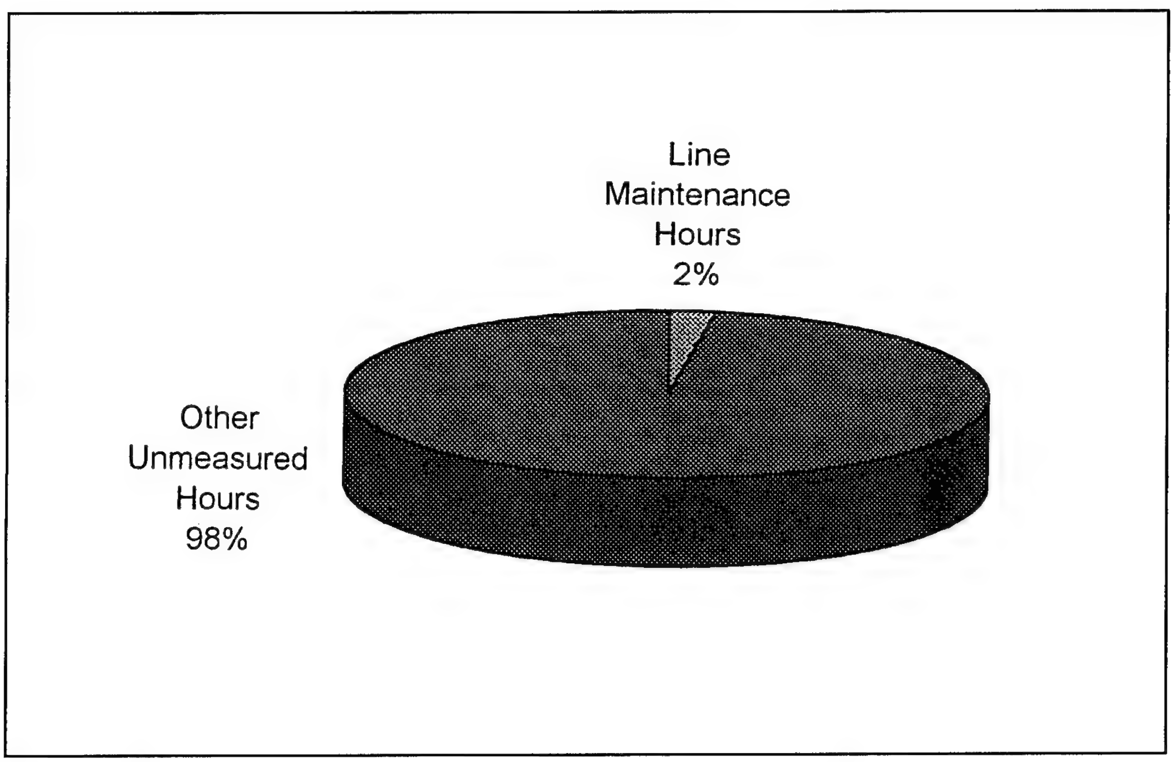

Figure 7. Line maintenance hours vs. other unmeasured hours.

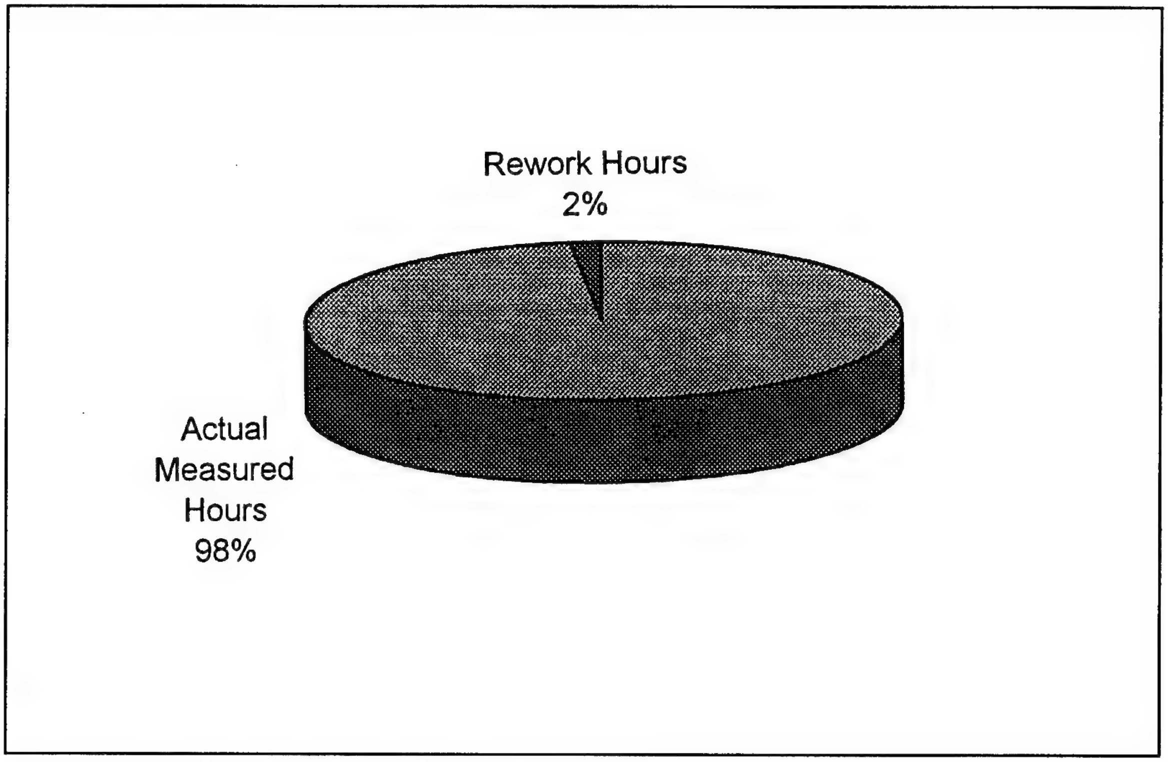

Figure 8. Rework hours vs. total measured hours.

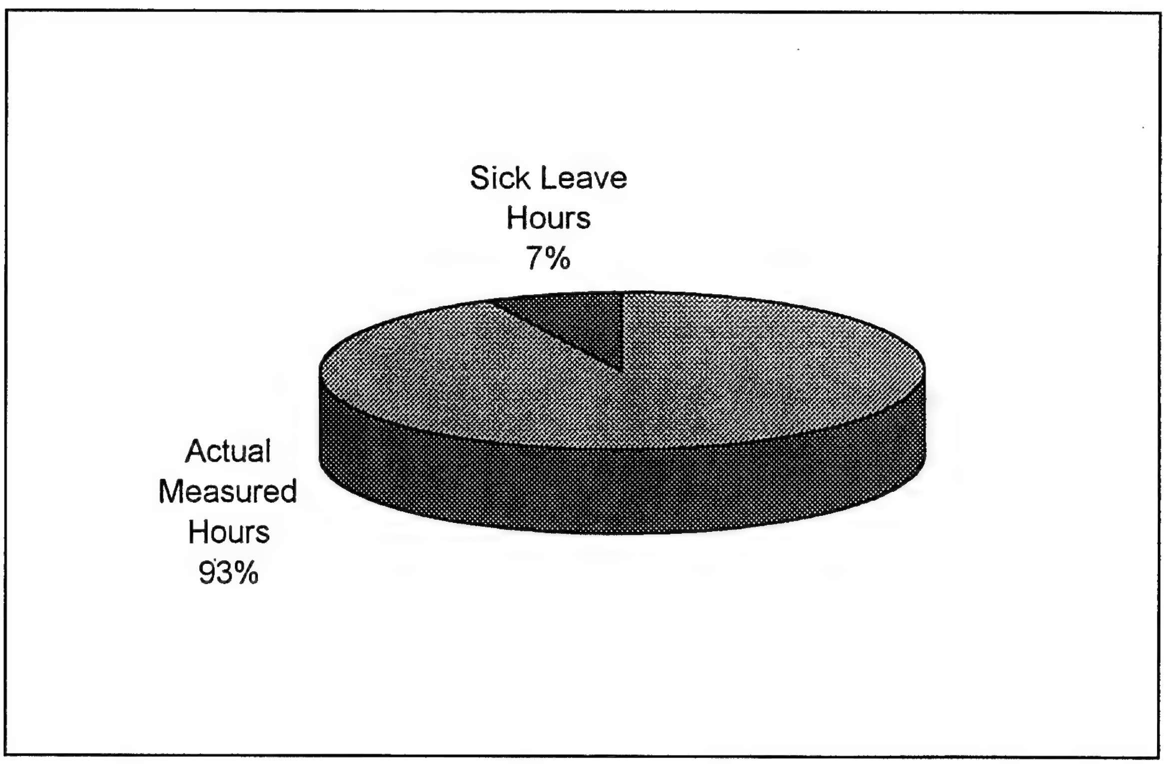

Figure 9. Sick leave hours vs. total measured hours.

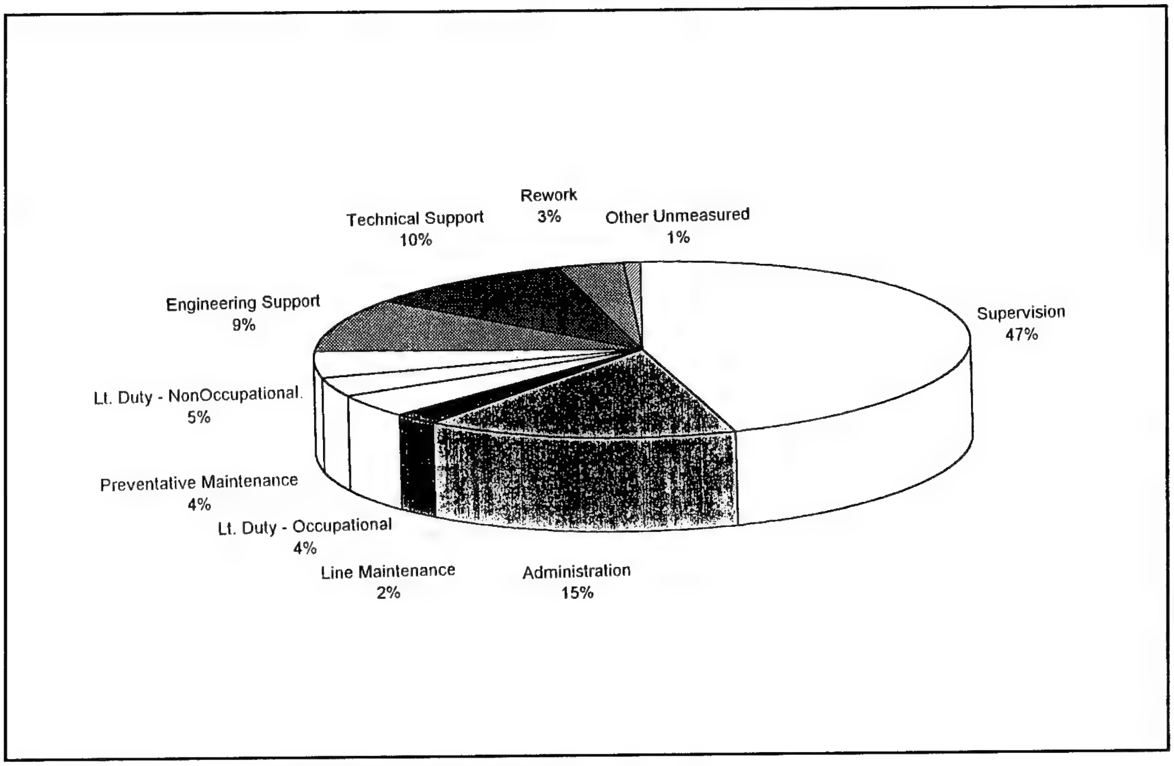

Figure 10. Breakdown of unmeasured hours.

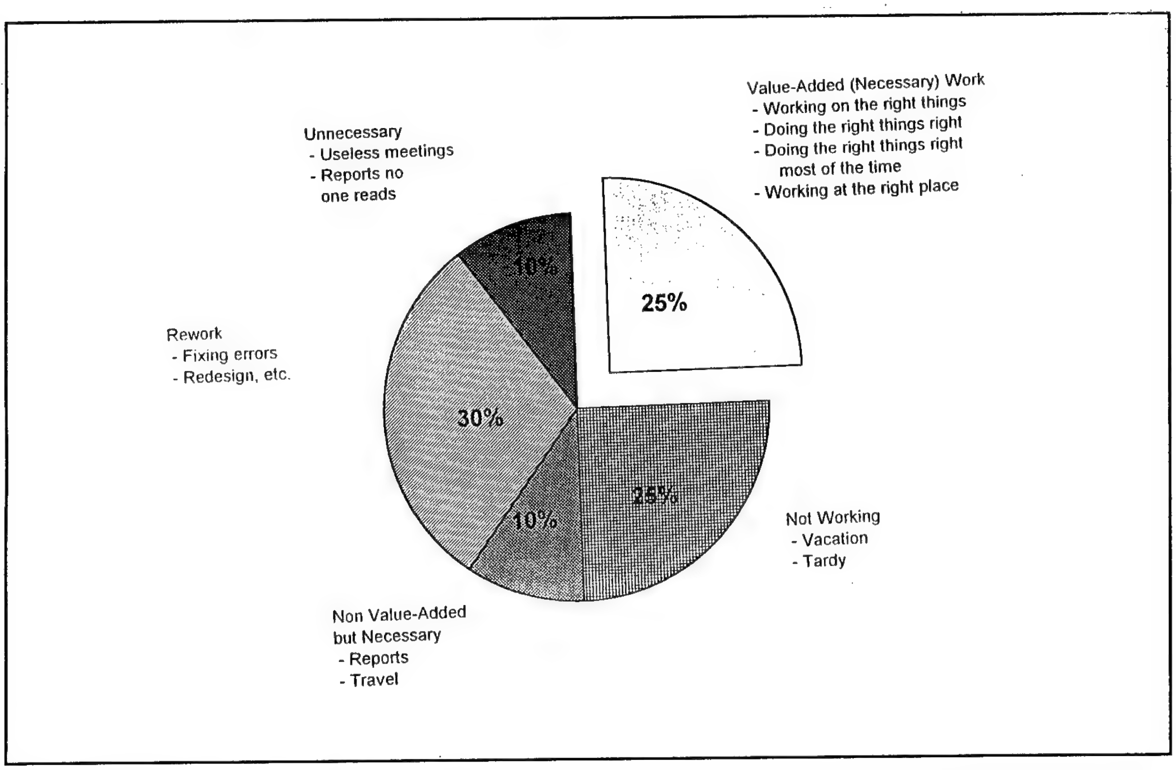

Figure 11. Average time spent on value-added and non-value-added work.

This survey shows that the time spent on value-added work (actual work on a project) amounts to 25 percent of the total time; PBA records that 37 percent of the total labor hours were used in the actual production of the smoke grenades for Job #AB033/4208C.

Proposed Process Improvements for Glatt Line

The Glatt line was not analyzed extensively during the Level I audit because most of the problems appeared to occur in the fill and press line. Consequently, PBA did not supply USACERL with supporting data for the Glatt line. The only bottleneck in the Glatt operation was reported to be due to the TA drying time (Step 16).

In addition, a fire occurred in the Glatt line during the Level I audit conducted at PBA that shut down manufacturing operations. USACERL researchers analyzed possible causes for the fire and concluded that its cause was related to material handling operations.

Process Improvement 1—Reduce Drying Time

Problem: One-third of the Glatt mixing process is dedicated to drying the TA. This step incurs energy costs and produces a bottleneck in the process.

Analysis: Decrease the drying time by decreasing the water used to mix additives. This would increase the solids by 4 percent, but the drying time could be reduced by 25 percent. This will increase the production capacity by removing a bottleneck in the process.

If 10 minutes were cut from the Glatt process by reducing the drying time to 30 minutes, the line could produce another batch per day:

(63 shifts) (4 batches/shift) = 252 batches

Calculating the number of shifts required if PBAs productivity went up by one batch/shift:

252 batches/5 batches/shift = 51 shifts

Calculating the savings in salary attributable to eliminating 12 shifts by increasing the work day by 1 batch:

(cost of Glatt process) ÷ (# of shifts) = $/shift

cost of Glatt process	= (63 shifts x 7 people/shift x 10 hours/shift x $116.75/hour)
	= $51,486.75
$51,486.75÷ 63	= $8,172/shift
63 shifts - 51 shifts	= 12 shifts
(12 shifts) ($8,172)	= $98,069.90 labor savings

Process Improvement 2—Correct Handling of Supersacks (TA)

Problem: The TA is shipped in large, fabric-wrapped supersacks that measure about 4 x 4 x 4-ft. The TA is then poured from the supersacks into a hopper attached to a forklift and then into 44-gal drums for weighing. The number of times that the TA is handled causes some spillage that is both economically wasteful and may be hazardous to workers and the environment. (See "Employees' Health and Safety," Chapter 4.)

Analysis: The TA is purchased from a supplier who, according to on-site personnel, only delivers TA in the fabric-wrapped bales. The gross spillage caused by receiving TA in the fabric-wrapped bales accounts for about 5 percent of the TA used (at $1.45/lb delivered). In addition, reducing spillage would decrease negative environmental effects and employee health problems and their costly remediation. AMOCO (TA manufacturer) has been contacted and has agreed to train PBA personnel in the correct method of handling supersacks.

Savings. The number of units produced in the 4-month production run for Jobs #AB033/4208C was 233,312. From the master bill of materials (Table 1), 450 lb of TA are needed per 1,000 grenade units produced:

233,312 units produced x 450.00 lb. TA/1,000 units x $1.45/LB TA = $152,236

cost of 5 percent spillage = 0.05 x $152,236 = $7,611/per production run.

Process Improvement for the Fill and Press Line

Most of the simple payback periods are very low, ranging from several hours to several years. (This speaks to the efficacy of the Phase I analysis that pared down all the suggested strategies to those deemed most viable.) The force driving many of these incredibly attractive paybacks is that more than $20,000 worth is attributable to each production hour. Incremental savings in production time translate into significant dollar savings. The numbers that accompany each of the following concepts correspond to the numbers used in the brainstorming performed in the Level I audit. (See Tables B3, B4, and B5 in Appendix B.)

Capacity Concepts #5 and #9—Replace Fast Conveyor

Description: At present, the major bottleneck in the TA smoke grenade production process is the fast conveyor used to transport the grenades through the processes wherein they are filled with smoke-producing ordnance and starter devices (process steps #11 to 14 [Figure 2]). This fast conveyor is a separate conveying device from those conveyors used to convey the product through process steps #1 to 10 and through all process steps subsequent to step #14. The fast conveyor breaks down often, according to the information received from the PBA technical staff.

Table 1. Master bill of materials by product number.

FSN	Line	Stock Description	UI	Net Quantity per 1000	Overage per 1000	Gross Quantity per 1000	Std Unit Price	Cost per 1000
330002939516	F/P	Fuse M201A1	EA	1000.0000	040.0000	1040.0000	001.729	1798.160
33001X932244	F/P	Top Assy M18	EA	1000.0000	150.0000	1150.0000	000.271	0311.650
33001X932245	F/P	Body Asy M18	EA	1000.0000	150.0000	1150.0000	000.534	0614.100
033001X960304	F/P	Cup, Starter	EA	1000.0000	100.0000	1100.0000	000.117	0128.700
099001X933821	LAP	Pallet	EA	0001.1570	000.0230	0001.1800	020.781	0024.521
031501X920809	LAP	Nail	BX	0000.0600		0000.0600	026.000	0001.560
081001X932312	F/P	Thin EN GR B	GL	0003.0000	001.0000	0004.0000	001.816	0007.272
081001X932434	M	Binder Mix	LB	0009.0000	001.0000	0010.0000	003.479	0034.790
081001X933839	M	Pot Chlorate	LB	0151.0000	024.0000	0175.0000	000.525	0091.875
081001X933840	??	Pot Nit Cl 1	LB	0006.4890	000.9085	0007.3975	001.064	0007.870
081001X933852	LAP	Alcohol	LB	0007.0000	003.0000	0010.0000	001.155	0011.550
081001X933967	S	Charcoal	LB	0000.7269	000.1454	0000.8723	002.040	0001.779
081001X933970	M	Mag Car.Gr B	LB	0035.0000	005.0000	0040.0000	000.764	0030.560
081001X933973	S	Silicon Powder	LB	0004.8106	000.9621	0005.7727	001.757	0010.142
081001X952092	M	Acid Tercpht	LB	0400.0000	050.0000	0450.0000	001.376	0619.200
0510001610811	F/P	Ink Marking	GL	0000.0300		0000.0300	010.994	0000.329
051001X932441	?	Conditioner	GL	0000.0081		0000.0081	021.740	0000.176
051001X933865	?	Ink White	GL	0000.2000	000.1000	0000.3000	056.641	0016.992
051001X960189	?	Compound	JR	0000.1000		0000.1000	147.900	0014.790
069001X921745	LAP	Label Hazard	RO	0000.1250	000.0010	0000.1260	031.587	0003.979
001001X920151	?	Enamel Whi	PL	0000.0300		0000.0300	058.649	0001.759
001001X932340	?	Enamel Alkyd	CN	0000.3000		0000.3000	078.983	0021.294
0040006826817	?	Adhesive Lab	GL	0000.0250		0000.0250	010.250	0000.256
011501X933901	LAP	Box, Wood	EA	0062.5000	000.5000	0063.0000	006.642	0418.446
0135002830670	LAP	Strapping	CL	0000.1620	000.0240	0000.1860	036.749	0006.835
013501X860336	?	Tape	RO	0000.8500	000.1000	0000.9500	036.173	0034.364
813501X932288	?	Tape Press	RO	0000.9160	000.2500	0001.1660	004.284	0004.995
813501X932354	LAP	Sheet FB	EA	0315.0000	045.0000	0360.0000	000.119	0042.840
813501X932449	LAP	Filler FB	EA	0125.0000	035.0000	0160.0000	000.074	0011.840
813501X932452	LAP	Strapping	LB	0009.3500		0009.3500	000.544	0005.086
813501X932460	F/P	Disc	EA	1000.0000	100.0000	1100.0000	000.005	0005.500
813501X933918	LAP	Seal Strap	BX	0000.0029	000.0004	0000.0033	062.520	0000.206
814001X932461	LAP	Container	EA	1000.0000	020.0000	1020.0000	000.413	0421.260
814001X932462	F/P	Collar, Fusc	EA	1000.0000	020.0000	1020.0000	000.060	0061.200
892501X932378	M	Sugar Confcc	LB	0095.0000	005.0000	0100.0000	000.346	0034.000
TOTAL COST								$4800.476

When the fast conveyor goes down, production must cease until it is again operable. Site personnel estimate the fast conveyor downtime to be 40 percent of the total downtime for fill and press.

This strategy proposes to replace the fast conveyor with a belt conveyor that PBA has already purchased. First cost will be the time taken to install the new belt:

(24 hours x cost of 3 workers) = (24 hours x $68.68 x 1.7 x 3 workers) = $8406.43

Assumptions. Reduce the downtime by 10 percent (3,333 hours down time).

Analysis. Savings associated with a 10 percent reduction in downtime are calculated as follows:

(0.40 x3,333) x (0.1)x(cost/production hour.) = savings per production run

Savings.

1,333 hours x 0.1 x $68.68 x 1.7 = $15,564

Simple payback maybe calculated by dividing first cost by cost savings:

Simple Payback.

$8,406/$15,564 x 63 days per production run = 34 days

#14—Install Failure Indicator Light

Description. At present, an alarm light is located in a control room that is rarely manned. This light enunciates an alarm whenever there is a failure in the fast conveyor. Operating personnel must discern that the reason for the production line stopping was a failure in the fast conveyor. Once this is agreed on, they must walk over to the fast conveyor to see if it has, in fact, failed. This entire process is extremely time consuming.

This strategy proposes to install a failure indicator light at the fast conveyor. This light would be tied into the existing programmable logic controller (PLC) that detects failures and sends the signal to the annunciation light in the control room. This new light will give visible annunciation of fast conveyor failure to persons out on the production line, allowing them to respond to the failure more quickly.

Assumptions. Per site personnel, it is assumed that this indicator light will increase production 1 percent.

Analysis. The first costs of this strategy are minimal: red failure indicator light in industrial screened protector, as well as junction boxes, conduit, wire, reset switch, and relay to interlock the light into the existing PLC. These first costs amount to $5,673 (means electrical).

Savings from a 1 percent increase in production are calculated as follows:

Savings.

630 production-hours. x (0.01) x $20,538.72/production hour

= $129,394 per production run.

Simple payback maybe calculated by dividing first cost by cost savings:

Simple Payback.

$5,673/$129,394 x 63 days per production run = 2.8 days

#39—(Option #1) Lease Air Compressor

Description: The existing central compressed air system provides dirty, oily compressed air that causes problems with the TA smoke grenade process equipment that utilizes compressed air. In addition, the entire central air system fails periodically. Site personnel estimate that, because of these two situations, the fill and press line is down 30 minutes per month.

This strategy proposes to lease an air compressor and connect it to the compressed air piping in the building housing the fill and press line, thereby removing the fill and press line from the central compressed system. This would require some reworking of the compressed air piping serving the fill and press building. The rented air compressor would be installed and operated as the primary air compressor, with the central system capable of being used as a back-up system, if necessary. A manual shutoff valve would be installed between the two systems. In addition, the rented compressor would have to be valved off so it could be serviced or exchanged periodically.

Assumptions. A 160 CFM diesel compressor would be required. The specified compressor uses an average of 1.25 gal of #2 diesel fuel per hour operation. (This figure was developed from a survey of three compressor rental companies in the Champaign, IL, area: McCabe Bros., Kemper Industrial Equipment Rental, and Rental City. Estimates of diesel consumption ranged from 1.0 to 1.5 gal/hour.)

The fill and press line downtime of 30 minutes per month (approximately 2 hours per production run) is due to central air problems.

Analysis: Implementing this strategy entails both first costs and operating costs. The first costs consist of the costs to modify the existing compressed air piping (example, install shutoff valve to isolate fill and press compressed air piping from central system) and the cost of cleaning out the existing compressed air piping, approximately $12,276. The operating cost consists of the annual rental fee and the fuel costs:

fuel costs = 630 production hours x 1.25 gal/hour x $1.20/gal
= $945/production run

annual rental cost = $7,380
rental for production run period

= $7,380/3 (630 hours is approximately one third of a working year.)
= $2,460

cost = fuel costs + rental cost per production run
= $945 + $2,460
= $3,405/production run.

Savings.

2 production hours per run x $20,538.72/production hour = $41,077

Savings.

Payback = (First Cost)/(Savings–Operating costs) x 63 days/production run
= $12,276/($41,077 - $3,405) x 63
= 20.5 days

#39 (Option #2)—Buy Diesel Fuel Air Compressor

Description: This strategy proposes to buy a diesel fuel air compressor and connect it to the compressed air piping in the building housing the fill and press line. This strategy was not discussed in the on-site brainstorming sessions. However, USACERL investigated it as an alternative to leasing an air compressor over a long time period of time.

This strategy would require some reworking of the compressed air piping serving the fill and press building. The purchased air compressor would be installed and operated as a back-up air compressor to the central compressed air system. This back-up compressor would be integrated as follows. A check valve would be installed between the main system and the compressed air piping serving the fill and press building. Two pressure transducers (low pressure and high pressure) would be installed in the fill and press compressed air piping. When pressure in the fill and press piping falls below setpoint due to malfunctioning of the central compressed air system, the low pressure transducer sends a signal that brings the newly purchased compressor on line. Once it brings the fill and press compressed system up to pressure, the high pressure transducer sends a signal that shuts off the new compressor, and the fill and press building goes back on the central compressed air system. However, this does not alleviate failures due to oil and dust, only the central system failure.

The advantage of purchasing a new compressor and installing it in the foregoing manner is that PBA alleviates the need for paying the annually recurring compressor rental cost. By operating the newly purchased compressor as a back-up compressor, run time is minimized, so maintenance costs are minimized.

Assumptions. A 160 CFM diesel compressor is required.

The compressor uses an average of 1.25 gal of #2 diesel fuel per hour of operation. (This figure was developed from a survey of three compressor rental

companies in the Champaign, IL, area: McCabe Bros., Kemper Industrial Equipment Rental, and Rental City. Estimates of diesel consumption ranged from 1.0 to 1.5 gal/hour. The compressor operates 30 minutes per month (approximately 2 hours per production run of 63 days) due to central air problems.

Analysis. Implementing this strategy entails both first costs and operating costs. The first costs consist of the costs to modify the existing compressed air system, amounting to $12,276 (explained above) and the cost of purchasing a new compressor ($16,835). The operating cost consists of the fuel costs:

operating costs = 630 production hours per run x 1.25 gal/hour. x 1.20/gal
= $945

savings = 2 hours/production run x $20,538.72/production hour
= $41,077.44

Payback = (first cost)/(savings-annual operating costs)
x production run
= ($16,835 + $12,276)/($41,077 - $945) x 63 days
= ($29,111)/($40,132) x 63 days
= 45.7 days

#39 (Option #3)—Buy Natural Gas Powered Air Compressor

Description. This strategy is an adaptation of natural gas engine-driven compressors that have been around for several decades. In 1995 the Industrial Gas Technology Commercialization Center developed a consortium of gas companies to participate in the development of a market for natural gas engine-driven compressors. The competitive advantages of gas engine-driven air compressors are due to lower overall costs to produce compressed air, higher part-load efficiency, compressed air available during electrical interruptions, and reduced peak electrical requirements. Further increases in efficiency are gained by using the heat generated by the gas compressor in the manufacturing process. In the case of the Glatt, steam is used to preheat the bowl and its components, then more heat is required for the fluidizing air.

A compressor situated at the manufacturing site rather than at the boiler house would eliminate long runs of supply line, and costs savings due to this relocation were estimated at $98,000 per year for electric power and $2,380 in air losses (Reynolds, Smith and Hills, Inc.).

Operating Costs. A 160 hp air compressor uses 8500 Btu/hp-hour of natural gas. The PBA production hours per run are 630. The Limited Energy study for PBA by Reynolds, Smith, and Hills report the cost of gas per MBtu for PBA is $2.81.

Natural gas fuel costs per production run are:

8500 Btu/hp hour x 160hp x 630 hours per production run
x $2.81/MBtu x one MBtu/106 Btu
= $2,407.61

Cost of a 160 hp natural gas air compressor is approximately $47,840 (Industrial Gas Technology Commercialization Center).

The cost for installing the new compressor is estimated at $12,276 (see #39 option 1).

first cost = cost of compressor + cost of installation = $47,840 + $12,276 = $60,116.

Savings.

If this solution saved 30 minutes per month of the production time, the savings would be:

2 hours x $20,538 = $41,076

This totals $98,000 power costs for partial loaded electrical compressors per year. Assume that the TA smoke grenade process is approximately one-third of a year, then the cost is $32,634.

Simple Payback.

(first cost)/(savings) x 63 days
= ($47,840 + $2,408 + $12,276)/($41,076 + $32,634) x 63 days
= ($62,524)/($73,710) x 63 days = 53 days

#7—Install Good Dust Collection System

Description. A considerable amount of dust is generated in the fill and press area. This dust enters fill and press equipment bearings and causes the machinery to fail. It is estimated that failures due to dust cause 10 percent of the fill and press downtime. This is 10 percent of the total downtime of 3,333 hours for fill and press.

Assumptions. The dust collection system on the north side of the building does not have sufficient capacity to serve the fill and press area. The cost of a new dust system was estimated from available commercial literature to cost $18,457.

Analysis. The dust collection system must be interfaced with the existing fire alarm system (FAS). The interface would shut down power to the dust collection system if the FAS enunciates an alarm.

Downtime for F&P on AB033/4208C	= 3,333 hours.
Cost of 10 percent downtime for F&P	= 0.1 x 3,333 hours x $68.68 x 1.7
	= $38,915
cost of new dust system	= $18,457
potential savings for job #ab033/4028c	= ($38,915 - $18,457)
	= $20,458

Simple Payback.

first cost/savings x days of operation	= ($18,457/$20,458) x 63 days
	= 56 days

#66 - Reevaluate Critical Dimensions

Description. At present the quality of materials varies in some parts of the TA process. Wide variations in the dimensions of these materials produce inferior grenades that must be scrapped. This strategy proposes that PBA personnel perform inspection of the dimensions of all materials received at PBA and perform prescreening to flag those materials that are outside of the required specifications. If the tolerances are included in the procurement specifications, the supplier should pay for the return and replacement of poor quality materials received by PBA.

Assumptions. There are sufficient personnel presently available to perform quality control (QC). Disposal cost/unit is double the production cost/unit. There are 20 rejects/day attributable to poor dimensions.

Analysis. Calculating the cost of the scrapped material:

savings = 20 units rejected/day x ($35.82/unit) x (63 days) = $45,133

Because there are no first costs involved, the payback is immediate.

#24 - Pre-Assemble Cup, Slug, and Starter

Description. These process steps are performed on the fast conveyor line. This strategy proposes to take these steps off-line and have them performed in a subassembly area. In effect, this strategy will have the same effect as carting the grenades around the fast assembly area: the fast conveyor is by-passed and the down time caused by using the fast conveyor is alleviated.

Assumptions.

- Capacity increased by 1 percent.
- Stainless steel carts are required to adequately transport grenades.
- There are sufficient personnel to assemble grenades off-line (no new personnel will be required).

Analysis. First cost consists of setting up the subassembly area (example, buying the eight equipment carts [$8,000] and making the minor modifications [$3,500] necessary to accommodate the carts in a sub-assembly area). Given that sufficient personnel are already present, there are no operating costs (example, extra salary).

Increasing capacity by 1 percent by assembling the grenades off line may be calculated as:

(Production hours.) x (0.010) x (cost/production-hour) = Savings for production run

Savings.

630 production hours x 0.010 x $20,538.72/production-hour = $129,389

Simple payback maybe calculated by dividing first cost by cost savings:

Simple Payback = $11,500/$129,389 x 63 days = 5.6 days

#41 - Combine Twist and Torque

Description. Installing smoke grenade fuses is accomplished in two steps (Steps #23 and 24 in Figure 2). A two-person crew threads the fuse into place "hand-tight" (Step #23), then a one-person crew applies the proper torque to the fuse using a torque wrench (Step #24). Currently, personnel exchange twist and torque duties to avoid injuries due to excessive repetition of one motion.

This strategy suggests combining the twist and torque steps into one step, which would eliminate one of the present twist positions. Each of the remaining two personnel would perform both twist and torque of fuses.

Assumptions. One of the twist positions could be eliminated without slowing down production.

Analysis. Savings due to eliminating one full-time position on the line can be estimated by multiplying the average, fully-burdened line worker's wage times the average number of hours worked each production run:

Savings = $116.75/hour. x 630 production-hours = $73,552/production run

Since there are no capital costs, the payback is immediate. However, this job would require the worker to perform repetitive actions over prolonged periods of time and may lead to injuries that would require an extended convalescence. (See Section 4. Employees' Health and Safety.)

#68 and #69—Optimize Maintenance Support/Optimize Training to Support Goals

Description. At present the personnel designated as "floaters" on the line are responsible for repairing simple breakdowns on the fill and press line. For more serious breakdowns, the floaters must place a call to PBA maintenance. The fill and press line remains down until maintenance crews arrive and fix the problem.

This strategy proposes to train the floaters to be mechanics. Given this capability they would be able to repair breakdowns on the fill and press line without having to call and wait for mechanics from another building.

Assumptions:

- Training fill and press floaters to be mechanics falls within their job description and capabilities.
- Fill and press downtime will be reduced by 10 percent.
- Transfer of funds will "pay" for PBA mechanics to train floaters.

Analysis. Training costs were estimated by taking the average hourly burdened rate of fill and press line workers ($116.75/hour), assuming it to be the average

burdened rate of PBA mechanics, and multiplying by the number of work-hours that would be consumed in training. USACERL assumed that four fill and press personnel would be trained as mechanics and one PBA maintenance mechanic would conduct the training. Three weeks of training would be invested in each of the floater/mechanics.

Savings. Savings due to a 10 percent decrease in fill and press downtime can be calculated as:

savings = (downtime) x (0.10) x (cost/workhour)

= 3,333 x (0.10) x $116.75/hour = $38,914

Cost of training 4 people plus the cost of one instructor
= $116.75/hour x 5 persons x 40 hours/week x 3 weeks
= $70,050

Simple Payback. Simple payback may be calculated by dividing first cost by cost savings:

($70,050)/($38,914) x 63 days = 113 days

Environmental Concepts: #1—Total Enclosure of Painting Operation

Description. The environmental costs associated with painting are that the overspray does not all go through the filter, rather it is deposited on the bearings of other equipment in the room. Another problem that may be investigated is that of proper filter change-out of packbed and proper blower size if the water-curtain is used.

Assumptions. The paint booth is well maintained. It is not totally enclosed but can be made so if another side is added without impending other operations. Special plastic additions to the paint booth could correct the problem. Five percent of the Fill and Press downtime is due to bearing failure on other equipment caused by paint overspray. Saving the 5 percent by covering the paint booth is calculated as:

savings = (downtime for fill and press operation) x (median cost of labor per hour)

x (multiple for overhead) x (5 percent) = savings

3,333 downtime hours x $68.68 x 1.7 x.05 = $19,457

Analysis. Design and manufacture of plastic hood for the paint booth is available at local tent and awning manufacturers.

Material needed is:

Plastic 20 millimeters thick at $6.00/ square yard	$600
Aluminum one in. square frame 80 ft	$240
Fabrication	$800
Total cost	$1,640

The operation and maintenance is minimal.

Payback: Simple payback can be calculated as:

[(first cost)/(cost savings)] x (number of hours in 4 month production run)

($1,640)/($19,457) x 63 days = 5.3 days

#2 - Evaluate Feasibility of Permanent Reject Grenade Demanufacture

Description. The reason for demanufacturing the permanent rejects is to reduce waste disposal. The Summary Scrap/Rework Cost Monthly Report for the manufacturing of M83 Training Grenades states that $7,499 was spent for scrap in May, $7,218 for April, $10,155 for March, and $2,977 for February, a total of $27,849 for scrap in 4 months. The reported number of good parts completed in May was 38,432, for April 38,096, for March 81,120, and for February 75,664, a total of 233,312 parts completed. Of the permanent rejects for the order, 1,905 grenades were rejected because of bad seals; 586 had damaged bodies and lacked tops; 1,012 had damaged bodies and included tops; 475 were low fill; and 24 had wrinkled bodies, a total of 4,002 rejects.

Analysis of Good Parts Produced. The net value costs included direct labor rate, administration rate, support rate, and direct materials/components. The total net value cost for May was $1,382,947 and April $1,364,515, an average of $1,373,731. Of the 4 months reported, only 2 months had net value cost/unit: May $36 and April $35.82. The average net value cost/unit $35.91 was used. This includes the cost of manufacturing scrap:

Costs.

Fuse	$1798.16
Starter cup	$128.70
Glatt mix	$807.76
Total	$2,724.62

Total costs for 4 months (4,002) or 4 (1,000) = ($2,724) x (4) = $10,898

Cost of avoidance of waste disposal ($10/LB) (0.5 LB each) = $20,000

Total savings of material from demanufacture

= (Total for 4,000 parts) + (Cost avoidance of waste disposal) - (New cans)

= ($10,898.48) + ($20,000) - ($3,700)

= $27,198

Cost for one person to remove the good parts for reuse:

$116.75/manhour x 10 hours x 63 days/production run = $73,553

Simple Payback.

(First cost)/(Savings) x 63 days = ($73,553)/($27,198) x 63 days = 170 days

#6 - Convert the Water Curtain to Dry Filters

Description. Waste from the air scrubber is paint sludge. The weight of the paint sludge for January and February amounted to 1,765 lb, which is 25 percent water (441 lb). At $10/lb disposal cost, the total cost for 2 months was $17,650. The cost of disposal of the water component is $4,410. Some wet scrubbers can be modified to change them to dry scrubbers and to use disposable filters. The cost for one person to clean out the paint booth is estimated at the fully burdened labor rate of a lineworker. Cleaning costs for one person to clean out the paint booth (coat and peel operation) after each run is:

4 hours x $68.68 x 1.7 = $467

Total cost per run for TA production (63 days) includes disposal of water in paint sludge and labor required to clean the wet scrubber.

Disposal of water in sludge	$4,410
Cost of labor	$467
Total	$4,877

Assumptions. The air scrubber at PBA does not contain a packed bed and that it can be modified to take disposable filters.

Analysis. Equipment needed to change the wet scrubber to dry scrubber:

Filter roll (6 ft by 100 ft by 1 in.) (tackafide)	=	$200
Frame for filters	=	$700
Pressure meter to measure the pressure drop across the filter	=	$1,500
Total	=	$2,400

Payback. Calculate the payback during the production run (63 days):

(first cost)/savings x 63 days = ($2,400)/($4,877) x 63 days = 31 days.

#24—Close Pretreatment Plant

Description. At present, PBA is meeting wastewater treatment standards without pretreatment plant operation. This strategy suggests closing the pretreatment plant.

Assumptions. Operating the pretreatment plant provides no benefit to the Arsenal.

- Save 50 percent of workhours for one person for the production run

- Save $2,333 (approximately)/(production run in UV lamp operation costs)
- Cost to mothball plant = $10K
- Laboratory analysis to confirm closing = $10K
- Total closing costs = $20K

Analysis. Calculating the savings in labor costs per production run:

630 production hours/run x (0.5) x $116.75/production hour = $36,776

Savings. Adding the labor savings to other operating savings yields annual savings:

$36,776 + $1,677 + $2,333 = $40,786

Simple Payback. Simple payback may be calculated by dividing first cost by cost savings:

$20,000/$40,786 x 63 days = 31 days

Energy Concepts: #4—Reduce Steam Pressure by 10 psig From 125 to 115 psig

Description. Steam pressure produced in the central boiler plants is 125 psig. No process load in the arsenal requires more than 75 psig. Steam is distributed at a pressure much higher than required, if this is actually the amount of steam received by the production line. Twenty-seven percent in losses of the natural gas consumption is lost in the 128 steam leaks (Reynolds, 1996 pp 3-5). This loss would equal approximately 34 psig if no corrections were made. However, if the installation corrected only a few leaks the reduction of 10 psig could be achieved without impacting the process. For example, if 12 traps were selected at $300 per trap the cost would be $3,600. Currently, when the steam pressure is reduced by as little as 10 psig, the manufacturing process is disrupted.

Assumptions:

- $1.66 million/year natural gas bill
- Existing boiler controls operable
- Cost of fixing 12 steam leaks is $3,600.

Analysis. Decreasing operating steam pressure by 10 psig yields on the average a 1 percent savings in annual fuel consumption. Calculating the annual savings for the entire installation resulting from simply decreasing the operating steam pressure:

(0.01) x ($1.66 million/year) = $16,660/year

Annual Savings.

($3,600)/($16,660) x 200 work days/year = 43 days

#26—Initiate Energy Team

Description. This strategy suggests forming an energy team consisting of five persons from advanced technology, design, energy, environmental, and production departments. The team would be responsible for identifying opportunities for saving energy, determining feasibility, and ensuring that all feasible opportunities are acted upon.

Assumptions.

- $3 Million per year annual energy bill
- Team can produce 10 percent annual energy savings
- Average cost per team member is $200/hour
- Team meets 10 times per year (2 hours per meeting)
- Team cost per year is ($200/hour) (5) x (2 hours) x (10) = $20,000

Analysis. Calculating annual savings:

Annual Savings = ($3 million/year) x (0.10) = $300,000/year

Simple Payback.

Simple payback maybe calculated by dividing first cost by annual cost savings:

$20,000/$300,000 x 200 work days/year (approximately) = 13 days

#10—Decommission Unused Steam Lines

Description. Approximately 8 miles of steam line serve the production areas of PBA. Large segments of these lines are not required for continued operation of production functions at PBA and may be decommissioned. Once these lines are decommissioned, PBA will realize savings in reduced line losses, reduced maintenance costs, and reduce steam leakage. Steam leaks cost PBA about $472,000/year (Reynolds, Smith, and Hills, Inc.). Of this steam leakage loss, 27 percent is attributed to steam leaks in areas 31, 32, 33, and 34 (the production areas of PBA).

Assumptions.

- Miles of steam line under consideration (46,720 lineal ft).
- Steam leakage losses in production areas account for 27 percent of total steam leakage losses at PBA.
- Percent of existing steam line in production areas may be decommissioned.

- Decommissioning will take 4 workers 2 weeks of work..
- For purposes of this analysis, take credit only for the savings in steam leakage (i.e., ignore maintenance and line loss savings).

Analysis. First costs are calculated as:

First Costs (4 men) x (80 hours/man) x ($68.68/hour) x1.7 = $37,362

Because 27 percent of the basewide steam leakage losses at PBA are attributed to the steam lines serving the production areas, the annual cost of steam leakage in these areas is calculated to be:

$427,000 x 27 percent = $115,290

Decommissioning 20 percent of the steam lines in the production areas will alleviate 20 percent of the annual costs of steam leaks. Annual savings from decommissioning steam lines is calculated as:

($115,290) x (0.20) = $23,058

Simple Payback.

Simple payback may be calculated by dividing first cost by annual cost savings:

($21,977)/($23,058) = 0.95 years

#5—Decentralize Steam System

Description. The production areas at PBA are served by five boiler houses. Steam in the production areas is used for space heating, process heating, and process humidification. Three of the boiler houses are connected by a 2-mile long, above ground common header (the "high line") and serve areas 31, 32, 33, and 34. Two boilers in Building 42-960 serve Area 42 (the incinerator area), and two boilers in Building 44-120 serve Area 44 (the LAP area). Boilers are fired with natural gas. Natural gas entering PBA is recorded by one utility meter. In addition to process usage, natural gas is supplied to about 71 other buildings at PBA for comfort heating and other miscellaneous uses (e.g., domestic hot water generation and laundry). This strategy is not exclusively concerned with the TA smoke grenade process but to manufacturing processes at PBA in general.

Assumptions.

- MBtu of natural gas lost per month due to steam leaks
- Using portable boilers during summer in production areas reduces line steam leakage by about two-thirds.

Analysis. The 1994 Contingency Master Planning Program Steam and Compressed Air Utility Study by CDG (the "CDG Study") disaggregates annual steam consumption at PBA. This study shows that, of the approximately 72,000 MBtu of natural gas used during the peak heating months at PBA (December and January), about half is consumed in providing space heating. During the

winter months of February/March and October/November, about one-third of the total natural gas used at PBA goes toward space heating. No steam is used for space heating in the production areas during the summer months of June through August and only about 2000 MBtu/month are used during the months of May and September. The CDG Study also shows that steam leakage losses are fairly constant throughout the year, at the level of 14,000 MBtu/month.

This strategy proposes to buy two small portable 5000-lb/hour boilers for use in the production areas during the summer. This would alleviate year-round firing of the three boiler houses serving areas 31, 32, 33, and 34. The two portable boilers could be used to generate the steam required for production loads in these areas, and steam leakage in the lines connecting the boilers houses to the production facilities would be eliminated. Assuming there would still be steam leakage for the lines inside the production facilities, a conservative estimate would place natural gas savings at 10,000 MBtu/month. PBA purchases natural gas for $2.81/Mbtu.

Annual Savings. Annual savings due to reduced steam leakage during the 5 summer months of May through September can be calculated as:

(10,000 MBtu/month) x (5 months/year) x ($2.81/Mbtu) = $140,500/year

Simple Payback.

With a first cost of $250,000 to buy the boilers, simple payback is calculated as:

($250,000)/($140,500/year) = 1.8 years

Table 2 gives a prioritized summary of the proposed optimizations for capacity, environmental, and energy.

Table 2. Prioritized summary of proposed optimizations.

Strategy	First Cost	Savings	Simple Payback
Capacity concepts Glatt line			
Reduce drying time	None	$98,069	Immediate
Correct handling of supersacks (ta)	None	$7,611	Immediate
Capacity concepts fill & press			
Capacity concept #66 Reevaluate critical dimensions	None	$45,133	Immediate
Capacity concept #14 Install failure indicator light	$5,673	$129,394	2.8 days
Capacity concept #24 Pre-assemble cup, slug & starter	$11,500	$129,389	5.6 days
Capacity concepts #5/#9 Replace fast conveyor	$8,406	$15,564	34 days
Capacity concept #7 Install good dust collection system	$18,457	$20,458	56 days
Capacity concept #39 (option 2)) Buy diesel fuel air compressor	$29,111	$40,132	45.7 days
Capacity concept #39 (option 3) Buy natural gas air compressor	$62,524	$73,710	53 days
Capacity concept #39 (option 1) Lease air compressor	$12,276	$37,672	20.5 days
Capacity concept #10 automate twist & torque	$45,280	$38,915	73 days
Capacity concepts #68/#69 optimize maintenance support/ optimize training	$70,050	$38,914	113 days
Environmental concepts			
Environmental concept #1 total enclosure of painting operation	$1,640	$19,457	5.3 days
Environmental concept #6 convert the water curtain to dry filters	$2,400	$4,877	31 days
Environmental concept #24 close pretreatment plant	$20,000	$40,786	31 days
Environmental concept #2 evaluate feasibility of permanent reject grenade demanufacture	$73,533	$27,198	170 days
Energy concepts			
Energy concept #4 reduce steam pressure by 10 psig	$3,600	$16,600	43 days
Energy concept #26 initiate energy team	$20,000	$300,000	13 days
Energy concept #10 decommission unused steam lines	$21,977	$23,058	0.95 years
Energy concept #5 decentralize steam system	$250,000	$140,500	1.8 years

4 Quality and Other Issues

Quality Concepts and Improvement

Quality is the loss associated with a product or service due to deviations from target values of product/service characteristics. Quality must start with design and the specifications; however, the customer is the final judge of a product's quality. Four aspects of quality should be considered in product design: functionality, maintainability, reliability, and reproducibility. All managers are concerned about quality of products and services, and the control of quality must begin long before products and services are delivered to the customer.

According to Philip Crosby (president of his own management firm, creator of the concept of "Zero Defects," who blames American business problems on poor management and not on poor workers), there is no reason for errors or defects in a product or service, i.e., "nonquality" (Crosby 1980). Following the concepts of quality management, dedicated work habits, and personal integrity make this a realistic goal. The quality management concepts to which Crosby adheres follow.

Management Commitment

Action. Discuss the need for quality improvement with management personnel, emphasizing the need for defect prevention.

Accomplishment. Help management to recognize that their commitment is toward raising the level of visibility for quality to the organization.

Quality Improvement Team

Action. Form a quality improvement team to include representatives from each department.

Accomplishment. The tools required to do the job are together in one team.

Quality Measurement

Action. Establish a baseline for quality throughout the company. Establish quality measurements for each area of activity.

Accomplishment. Formalize the company's quality measurement system.

Cost of Quality Evaluation

Action. Quality costs should be accurately assessed from the comptroller's office.

Accomplishment. Have the comptroller establish cost of quality.

Quality Awareness

Action. Share with employees the cost of nonquality products and services.

Accomplishment. Establishing communications that allow supervisors and employees to talk about quality.

Corrective Action

Action. Employees are encouraged to bring problems and ideas for correction to their supervisors.

Accomplishment. Employees see that problems are acknowledged and corrected.

Establish an Ad Hoc Committee for the Zero Defects Program

Action. Establish the committee to communicate to all employees the meaning of "Zero Defects" and the importance of doing things right the first time.

Accomplishment. The committee prepares to implement the program.

Supervisor Training

Action. Formal orientation of all levels of management should be conducted before implementation of the program.

Accomplishment. Supervisors will concentrate all of their efforts on the program.

"Zero Defects" Day

Action. Establish "Zero Defects" as the performance standard of the company in one day.

Accomplishment. Make a memorable day of "Zero Defects" Day.

Goal Setting

Action. Employees and supervisors establish the goals they would like to work toward. All goals should be specific and measurable.

Accomplishment. Help employees learn to think in terms of meeting goals and accomplishing specific tasks as a team.

Error Cause Removal

Action. Employees are asked to document problems that keep them from performing error-free work.

Accomplishment. Employees learn to trust this communication.

Recognition

Action. Award programs are established to recognize those who meet their goals or perform outstanding work.

Accomplishment. Employees will continue to support the program even if they do not actually receive an award.

Quality Councils

Action. The quality professionals and team chairpersons should communicate regularly and determine actions needed to upgrade and improve the quality program.

Accomplishments. Bring professionals together on a regular basis.

Do It Over Again

Action. After about a year taking into account turnover, a new team of representatives should be selected and begin again. This brings "fresh eyes" to the process to spot items overlooked previously.

Accomplishment. Repetition makes the program perpetual.

Summary

It is important to regard quality as an integral part of the TA smoke grenade process. Feedback and observations have shown that there is a lack of quality in some of the steps of the process. Quality must be maintained throughout the process. The corporate director at Firestone Tire and Rubber Company states that "for every dollar you spend on preventing defects, you save two dollars or more in reduced scrap, product failures and other costs" (Gaither 1990, p 687). In addition to reduced scrap, fewer machines are shut down to look for causes of quality problems, so reducing interruptions to production. An estimated 20 to 25 percent of the overall cost of goods sold is due to finding and correcting errors (Gaither 1990, p 688).

Kowalick (1992) shows that costs rapidly escalate if the majority of defects occur late in the product cycle. Counteracting defects early in the cycle prevent higher costs in later stages.

Employees' Health and Safety

Hazards are intrinsic in most manufacturing processes. Hazards may involve falling, being caught in machinery, or exposure to toxic chemical, noxious fumes, dust, and noise. Although safety standards for all areas of the industrial work environment are established and enforced, employees can still receive injuries or impairment to their health.

Some of the steps in the manufacturing of the TA smoke grenades lead to situations that may be hazardous to employees. Spillage of TA is a hazard to employees and economically wasteful. In June 1996, some Glatt mix was spilled and subsequently, a fork lift ran over the spilled mix, causing a fire.

The production department should interface with specialists who design safety devices and procedures; initiate good housekeeping concepts into the process, raise employee awareness, and design advertising programs to minimize hazards resulting from human error. These and other quality measures will help to protect employees and improve the process and the final product. When working conditions are safe, employee morale and productivity tend to increase, and accidents and downtime decrease.

Some preventive measures should be considered to avoid cumulative injuries caused by repetitive actions such as the twist and torque in the fill and press line. This action requires the worker to engage in a clockwise movement of the wrist and hand, a similar motion to inserting screw in holes. If the wrist is aligned with the forearm no problems will occur. However, if the wrist is bent in relation to the forearm, the tendons bend and bunch up in the channel known as the carpal tunnel. The carpal tunnel is formed by the bones of the back of the hand on one side and the transverse carpal ligament on the other. The radial artery, median nerve, and flexor tendons of the fingers pass through the tunnel, and the ulnar artery and ulnar nerve pass over the outside of the transverse carpal ligament. The ulnar nerve and ulnar artery also pass close to a small wrist bone (the pisiform bone). Continued twisting motion with a bent wrist may lead to tenosynovitis, an inflammation of the tendon sheaths of the wrist. Employees should be made aware of potential injuries that can occur from repetitive actions, such as the twist and torque, and the steps they can take to avoid such injuries. A key rule is to perform the task with the wrist aligned with the forearm.

Choosing Between Automation and Manual Operations

The following discussion offers some ideas regarding the perceived benefits of automation and manual operations, respectively (McCormick 1982). The information may be of assistance to production managers and engineers who make decisions on whether to automate certain steps of a process or to use manual labor. Table 3 reflects some capabilities in which humans seem to do better than machines, and Table 4 reflects abilities at which machines are more adept (McCormick 1982, pp 489-490). These comparisons should be viewed with caution for the following reasons (McCormick 1982, p. 491):

- general man-machine comparisons are not always applicable (computational ability of computers does not mean computers should be used whenever computations are required)
- lack of adequate data on which to base function allocation

- relative comparisons are subject to continual technological advancements
- it is not always necessary to provide the "best" performance (mechanical toll collectors perform an acceptable job, although humans offer some advantages)
- function performance is not the only criterion (availability, cost, weight, power, reliability, and cost of maintenance must be considered)
- function allocation should take into account social and related values.

The preceding discussion seems to indicate that there is no clear-cut method for deciding what system functions should be performed by people and by machine. The strategy of selecting machines or manual operations to perform a function should consider the operation of the system as a whole and not look at each function in isolation from other functions. The goal is to enhance the operation of the system as a whole.

Labor Standards

Gaither defines a labor standard as "...the number of worker-minutes required to complete an element, operation, or product under ordinary operating conditions. Standards are hierarchical. ...Each product has a standard, each major operation within each product has a labor standard, and each elemental task within each operation has a labor standard" (McCormick 1982, p 651). The term ordinary operating conditions is defined as a hypothetical average situation including workers' ability, workers' working speed, operation of machines, supply of materials, availability of information, etc.

Labor standards are dynamic and must reflect the methods actually used in performing every aspect of the work. As methods change, labor standards must change. If standards are not modified, they become obsolete and should not be used as planning and scheduling tools.

Table 3. Functions that human beings usualy do better than machines.

Sense very low levels of certain kinds of stimuli: visual, auditory, tactual, olfactory, and taste
Detect stimuli against high noise-level background, such as blips on cathode-ray-tube (CRT) displays with poor reception Recognize patterns of complex stimuli which may vary from situation to situation, such as objects in aerial photographs and speech sounds
Sense unusual and unexpected events in the environment
Store large amounts of information over long periods of time (especially principles and strategies)
Retrieve pertinent information from storage (recall), frequently retrieving many related items of information (reliability of recall is low)
Draw upon experiences in making decisions; adapt decisions to fit requirements; act in emergencies
Select alternative modes of operation, if certain modes fail
Reason inductively (generalize from observations)
Apply principles to solutions of varied problems
Make subjective estimates and evaluations
Develop new solutions
Adapt physical response to variations in operational requirements
Prioritize activities, when overload conditions prevail

Table 4. Functions that machines usually do better than human beings.

Sense stimuli outside the normal range of human sensitivity (x-rays, radar wavelengths, and ultrasonic vibrations)
Apply deductive reasoning (recognizing stimuli as belonging to a general class, when characteristics of class are specified)
Monitor for prespecified events, especially when infrequent (machines cannot improvise in case of unanticipated events)
Store coded information quickly and in large quantities (large sets of numerical values)
Retrieve coded information quickly and accurately (specific instructions must be provided as to type of information required)
Process quantitative information following specified programs
Make rapid and consistent responses to input signals
Perform repetitive activities reliably
Exert considerable physical force in a highly controlled manner
Maintain performance over extended periods of time
Count or measure physical quantities
Perform several programmed activities simultaneously
Maintain efficient operations under conditions of heavy load
Maintain efficient operations under distractions

5 Conclusions and Recommendations

Conclusions

This study has conducted a Level II audit of the TA smoke grenade process and has proposed process optimization concepts (Chapter 3) for the manufacture of TA smoke grenades at PBA to reduce waste and conserve energy.

In the current project, PBA management and technical staff worked closely with researchers from USACERL. The reason for the involvement of an outside agency was to start the process by looking at the current manufacturing process objectively to see where process improvement could occur, to train the installation personnel in process optimization, and to help integrate process optimization into the installation management philosophy. The process as bound by certain principles. For example, throughout the process, optimizing one system parameter, e.g., energy use reduction, was not to be gained by sacrificing another system parameter, for example, increasing pollution.

During the Level I audit on the manufacturing of TA smoke grenades, emphasis was placed on the fill and press part of the operation because the three main bottlenecks occur on this line. Most of the improvement ideas came from the Level I audit that included brainstorming sessions on site, involving PBA technical personnel, USACERL researchers, and contractors (Appendix B). Because problems on the Glatt, and load and packout lines were not exhaustively discussed during the Level I audit, most of the data from PBA relate to the fill and press line.

This study concludes that there are many improvements to the TA smoke grenade manufacturing process that can yield significant cost savings within reasonable payback times (some of which are immediate). Some of the proposed process improvements were calculated from the data supplied by PBA and engineering data from commercial manufacturers (Table 3, p 48). Many paybacks are predicated on as little savings as 1 percent of the production time. Some of the procedures such as "twist and torque" have been investigated previously and involve health and safety concerns as well as economic ones. Note that, while health and safety concerns are difficult to quantify, one worker off the line for 1 week would cost PBA an estimated $22,747 (Chapter 4).

In general, manufacturing downtime required for quality testing is time consuming and expensive. Quality control should start at the beginning of the process and be the responsibility of all those involved in the production process.

Recommendations

The following recommendations propose optimization primarily in the fill and press line of the TA smoke grenade manufacturing process (Table 3, p 48). Table 2 (p 48) lists estimated first costs, savings, and simple payback times of each of the following recommendations. The proposed optimizations are generally prioritized according to low first cost, high savings, and short, simple payback. Therefore, it is recommended that the concepts be adopted in the following order to obtain the best results in the shortest time:

1. *Capacity Concepts Glatt Line*[*]
   - Reduce drying time
   - Correct handling of supersacks (TA)
2. *Capacity Concepts Fill and Press*
   - Capacity concept #66: Reevaluate critical dimensions
   - Capacity concept #14: Install failure indicator light
   - Capacity concept #24: Pre-assemble cup, slug & starter
   - Capacity concepts #5/#9: Replace fast conveyor
   - Capacity concept #7: Install good dust collection system
   - Capacity concept #39 (option 2): Buy diesel fuel air compressor
   - Capacity concept #39 (option 3): Buy natural gas air compressor
   - Capacity concept #39 (option 1): Lease air compressor
   - Capacity concept #10: Automate twist & torque
   - Capacity concepts #68/#69: Optimize maintenance support/optimize training
3. *Environmental Concepts*
   - Environmental concept #1: Total enclosure of painting operation
   - Environmental concept #6: Convert the water curtain to dry filters
   - Environmental concept #24: Close pretreatment plant
   - Environmental concept #2: Evaluate feasibility of permanent reject grenade demanufacture
4. *Energy Concepts*
   - Energy concept #4: Reduce steam pressure by 10 psig
   - Energy concept #26: Initiate energy team
   - Energy concept #10: Decommission unused steam lines
   - Energy concept #5: Decentralize steam system

[*] Note that, since the conclusion of this study, PBA has redesigned the Glatt process and has written new SOPs. These recommendations do not reflect those changes, and may be superseded by the new processes.

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Appendix A: Production Division Monthly Labor Yield From PBA

PBA provided USACERL with Production Division Monthly Labor Yield reports. Job #AB033/4208C (M83 smoke grenades) was selected for analysis. The time period for this job was from February 1996 to May 31 1996. The data from the PBA report were entered into a spreadsheet to more easily allow data elements to be sorted into their respective activity codes.

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Totals

Jobs AB033/4208C Combined — TA Smoke Grenade

Activity Code	Net Units	Actual Hours Measured	Down Hours	Net Hours Measured	Actual Hrs Unmeasd	stat
835 Total	on-job trng		625			down
845 Total	dwntne comp		305			down
846 Total	defect comp		6			down
847 Total	adj of equip		182			down
850 Total	dmntm equip os		3019			down
851 Total	dwntme line chg		7			down
853 Total	dwntm samples		648			down
861 Total	dwntm inv fire		139			down
865 Total	dwntm weather		69			down
871 Total	dwntm lot no ch		73			down
	Total Down					5073
905 Total	annual lv				2343	leave
910 Total	S/L no dr stat				1316	leave
912 Total	S/L dr stat				340	leave
917 Total	sl care fam mbr				151	leave
920 Total	holiday lv				220	leave
922 Total	court lv				44	leave
924 Total	continue of pay				10	leave
925 Total	time off award				40	leave
933 Total	vol lwop				21	leave
940 Total	comp time work				66	leave
941 Total	comp time taken				84	leave
942 Total	TDY				51	leave
	Total Leave					4686
110 Total	prep start mix	170	5	165		meas
122 Total	prepare slugs	325	31	294		meas
124 Total	prep glatt mix	3349	952	2397		meas
128 Total	rebld glatt mix	886	15	871		meas
246 Total	punch screens	197	0	197		meas
309 Total	F&P south	14364	3840	10524		meas
524 Total	packout	659	109	550		meas
611 Total	clean-up	941	0	941		meas
614 Total	F&P inven 100%	489	116	373		meas
619 Total	P.O inv 100%	48	5	43		meas
	Total Meas.	21428	5073	16355		
710 Total	admin				9.5	ovrhd
713 Total	misc OH				28	ovrhd
721 Total	meetings				295.5	ovrhd
732 Total	post wide evac				69	ovrhd
733 Total	light duty				612	ovrhd

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Totals

Jobs AB033/4208C Combined

TA Smoke Grenade

754 Total	foreman sf cte				3	ovrhd
765 Total	training				601	ovrhd
770 Total	clerical				891	ovrhd
771 Total	timekeeping				6.5	ovrhd
773 Total	filing				8	ovrhd
782 Total	dispensary				98.5	ovrhd
786 Total	awards				32	ovrhd
787 Total	eeo activities				118	ovrhd
792 Total	official func				13	ovrhd
793 Total	caira/surety				4	ovrhd
796 Total	clean-up				3898.5	ovrhd
799 Total	comm counsl ctr				29	ovrhd
	Total Overhead					6716.5
650 Total	supervision				4705	unmeas
654 Total	Admin.				1594	unmeas
656 Total	Line Maint.				231	unmeas
660 Total	Lt. Duty/Occup				444	unmeas
		Prev. Maint.		384.5		
		Lt. Duty - NonOccu.		523		
661 Total	Prev Maint & Lt. Duty-NonOccup.				907.5	unmeas
662 Total	Engr Sup.				972	unmeas
663 Total	Tech Sup.				1025.5	unmeas
692 Total	Screen /Ven				27	unmeas
694 Total	Rework				333	unmeas
704 Total	EEO Couns.				60	unmeas
	Total Unmeasured					10299

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

Jobs AB033/4208C Combined

M83 Smoke Grenade

Month	Reprt Page	Activity Code	Job #	Activity Description	Net Units	Actual Hours Measured	Down Hours	Net Hours Measured	Actual Hrs Unmeasd	stat
31-May-96	9	835	AB033	On-job training			49			down
31-May-96	9	847	AB033	Adj of equip			31			down
31-May-96	9	850	AB033	Dwntime Equip			989			down
31-May-96	10	851	AB033	Dwntime line chg			4			down
31-May-96	10	853	AB033	Dwntm samples			216			down
31-May-96	10	871	AB033	Dwntm lot no ch			6			down
31-May-96				TOTAL			1295			down
31-May-96	4	905	AB033	annual					203	leave
31-May-96	4	910	AB033	sick no dr stat					49	leave
31-May-96	4	917	AB033	sl care fam mbr					13	leave
31-May-96	4	920	AB033	holiday lv					110	leave
31-May-96	19	905	AB033	annual					158	leave
31-May-96	20	910	AB033	sick no dr stat					52	leave
31-May-96	20	917	AB033	sl care fam member					7	leave
31-May-96	20	920	AB033	holiday lv					110	leave
31-May-96	20	933	AB033	voluntary lwop					14	leave
31-May-96	20	940	AB033	comp time work					6	leave
31-May-96	20	941	AB033	comp time taken					20	leave
31-May-96				TOTAL					742	leave
31-May-96	6	122	AB033	prepare slugs	12390	15	1	14		meas
31-May-96	6	124	AB033	prep Glatt mix	57	933.5	258	675.5		meas
31-May-96	6	128	AB033	Rebld Glatt mix	23	149.5		149.5		meas
31-May-96	7	246	AB033	Punch screens	77500	79		79		meas
31-May-96	7	309	AB033	F&P south	73747	4877.5	984	3893.5		meas
31-May-96	7	524	AB033	Packout	37216	317	24	293		meas
31-May-96	8	611	AB033	Cleanup	17	175		175		meas
31-May-96	8	614	AB033	F&P Inv 100% so	73747	158	27	131		meas
31-May-96	8	619	AB033	P.O. Inv 100%	37216	19	1	18		meas
31-May-96				TOTAL		6723.5	1295	5428.5		meas
31-May-96	2	710	AB033	admin					5.5	ovrhd

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

Jobs AB033/4208C Combined **M83 Smoke Grenade**

31-May-96	2	721	AB033	meetings					20	ovrhd
31-May-96	2	765	AB033	training					10	ovrhd
31-May-96	3	770	AB033	clerical					159.5	ovrhd
31-May-96	3	786	AB033	awards					9	ovrhd
31-May-96	3	792	AB033	official function					8	ovrhd
31-May-96	3	796	AB033	clean up					803	ovrhd
31-May-96	18	710	AB033	admin					4	ovrhd
31-May-96	18	721	AB033	meetings					20.5	ovrhd
31-May-96	18	765	AB033	training					2	ovrhd
31-May-96	18	770	AB033	clerical					151	ovrhd
31-May-96	19	771	AB033	timekeeping					6.5	ovrhd
31-May-96	19	786	AB033	awards					11	ovrhd
31-May-96	19	792	AB033	official function					5	ovrhd
31-May-96				**TOTAL**					**1215**	ovrhd
31-May-96	1	650	AB033	supervision					1386	unmeas
31-May-96	1	654	AB033	admin					147.5	unmeas
31-May-96	2	661	AB033	prev maintenanc					68.5	unmeas
31-May-96	8	656	AB033	Line maint					58.5	unmeas
31-May-96	9	694	AB033	Rework					83	unmeas
31-May-96	16	650	AB033	supervision					185	unmeas
31-May-96	17	654	AB033	administration					333	unmeas
31-May-96	17	661	AB033	prev maint					108	unmeas
31-May-96	17	662	AB033	engr support					276.5	unmeas
31-May-96	18	663	AB033	tech supt					397.5	unmeas
31-May-96				**TOTAL**					**3043.5**	unmeas
	MAY TOTALS									

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

Jobs AB033/4208C Combined

M83 Smoke Grenade

30-Apr-96	12	835	AB033	on job training			298			down
30-Apr-96	12	846	AB033	defect compon			6			down
30-Apr-96	12	847	AB033	adj of equip			87			down
30-Apr-96	13	850	AB033	dwntm equip os			799			down
30-Apr-96	13	853	AB033	dwntm samples			213			down
30-Apr-96	14	861	AB033	dwntm inv fire			106			down
30-Apr-96	14	865	AB033	dwntm weather			4			down
30-Apr-96	14	871	AB033	dwntm lot no ch			16			down
30-Apr-96				**TOTAL**			**1529**			down
30-Apr-96	5	905	AB033	annual					145	leave
30-Apr-96	5	910	AB033	sick no dr stat					87	leave
30-Apr-96	16	905	AB033	annual					930	leave
30-Apr-96	16	910	AB033	sick no dr stat					457	leave
30-Apr-96	17	912	AB033	sick dr stat					180	leave
30-Apr-96	18	917	AB033	sl care fam mbr					40	leave
30-Apr-96	18	922	AB033	court lv					20	leave
30-Apr-96	18	925	AB033	time off award					40	leave
30-Apr-96	22	905	AB033	annual					121	leave
30-Apr-96	22	910	AB033	sick no dr stat					57	leave
30-Apr-96	22	917	AB033	sl care fam mbr					5	leave
30-Apr-96	23	922	AB033	court lv					24	leave
30-Apr-96	23	933	AB033	voluntary lwop					5	leave
30-Apr-96	23	940	AB033	comp time work					31	leave
30-Apr-96	23	941	AB033	comp time taken					32	leave
30-Apr-96	23	942	AB033	TDY					15	leave
30-Apr-96				**TOTAL**					**2189**	leave
30-Apr-96	7	110	AB033	prep start mix	69	170	5	165		meas
30-Apr-96	7	122	AB033	prepare slugs	83930	112	1	111		meas
30-Apr-96	8	124	AB033	prep Glatt mix	64	1084	445	639		meas
30-Apr-96	8	128	AB033	rebld Glatt mix	46	264		264		meas
30-Apr-96	9	246	AB033	punch screens	86500	118		118		meas

Jobs AB033/4208C Combined

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

M83 Smoke Grenade

30-Apr-96	9	309	AB033	F&P south	7626	4109	962	3147		meas
30-Apr-96	9	524	AB033	Packout	36720	342	85	257		meas
30-Apr-96	10	611	AB033	clean-up	37	362		362		meas
30-Apr-96	10	614	AB033	F&P inven 100%	7626	155	27	128		meas
30-Apr-96	10	619	AB033	P.O. inven100%	36720	29	4	25		meas
30-Apr-96				TOTAL		6745	1529	5216		meas
30-Apr-96	3	713	AB033	misc overhead					8	ovrhd
30-Apr-96	3	721	AB033	meetings					9	ovrhd
30-Apr-96	3	732	AB033	post wide evacu					10	ovrhd
30-Apr-96	3	754	AB033	foreman sf cte					1	ovrhd
30-Apr-96	3	765	AB033	training					171	ovrhd
30-Apr-96	4	770	AB033	clerical					164	ovrhd
30-Apr-96	4	773	AB033	filing					8	ovrhd
30-Apr-96	4	782	AB033	dispensary					2	ovrhd
30-Apr-96	4	796	AB033	clean up					1950	ovrhd
30-Apr-96	14	704	AB033	eeo counselors					40	ovrhd
30-Apr-96	14	713	AB033	misc OH					2	ovrhd
30-Apr-96	14	721	AB033	meetings					62	ovrhd
30-Apr-96	14	732	AB033	post wide evacu					52	ovrhd
30-Apr-96	15	733	AB033	light duty					313	ovrhd
30-Apr-96	15	765	AB033	training					300	ovrhd
30-Apr-96	15	782	AB033	dispensary					43.5	ovrhd
30-Apr-96	16	787	AB033	eeo activities					4	ovrhd
30-Apr-96	16	799	AB033	comm counsl ctr					2	ovrhd
30-Apr-96	21	721	AB033	meetings					12	ovrhd
30-Apr-96	21	732	AB033	post wide evacu					7	ovrhd
30-Apr-96	21	765	AB033	training					88	ovrhd
30-Apr-96	22	770	AB033	clerical					132	ovrhd
30-Apr-96				TOTAL					3380.5	ovrhd
30-Apr-96	1	650	AB033	supervision					1403	unmeas
30-Apr-96	2	654	AB033	admin					250	unmeas
30-Apr-96	2	661	AB033	prev maintenanc					161	unmeas

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

Jobs AB033/4208C Combined — **M83 Smoke Grenade**

30-Apr-96	11	656	AB033	line maint					70.5	unmeas
30-Apr-96	11	660	AB033	lt duty-occup					70	unmeas
30-Apr-96	11	661	AB033	lt dty-nonoccup					20	unmeas
30-Apr-96	11	692	AB033	screen for vend					27	unmeas
30-Apr-96	11	694	AB033	rework FLT/prod					125	unmeas
30-Apr-96	19	650	AB033	supervision					125	unmeas
30-Apr-96	19	654	AB033	administration					342.5	unmeas
30-Apr-96	20	662	AB033	engr support					367.5	unmeas
30-Apr-96	21	663	AB033	technical support					342	unmeas
30-Apr-96				**TOTAL**					**3303.5**	unmeas
	APRIL TOTALS									

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

Jobs AB033/4208C Combined | **M83 Smoke Grenade**

31-Mar-96	10	835	4208C	on job trng			118			down
31-Mar-96	10	845	4208C	dwntme compon			14			down
31-Mar-96	10	847	4208C	adj of equip			45			down
31-Mar-96	10	850	4208C	dwntm equip os			970			down
31-Mar-96	11	853	4208C	dwntm samples			91			down
31-Mar-96	11	865	4208C	dwntm weather			65			down
31-Mar-96	11	871	4208C	dwntm lot no ch			29			down
31-Mar-96	18	835	AB033	on job training			90			down
31-Mar-96	18	845	AB033	dwntm compon			111			down
31-Mar-96	18	847	AB033	adj of equip			19			down
31-Mar-96	18	850	AB033	dwntm equip os			180			down
31-Mar-96	19	851	AB033	dwntm line chg			3			down
31-Mar-96	19	853	AB033	dwntm samples			109			down
31-Mar-96	19	871	AB033	dwntm lot no ch			11			down
31-Mar-96				**TOTAL**			**1855**			down
31-Mar-96	5	905	AB033	annual					128	leave
31-Mar-96	6	910	AB033	sick no dr stat					82	leave
31-Mar-96	6	924	AB033	continue of pay					10	leave
31-Mar-96	6	933	AB033	voluntary lwop					2	leave
31-Mar-96	21	905	AB033	annual					606	leave
31-Mar-96	22	910	AB033	sick no dr stat					502	leave
31-Mar-96	22	912	AB033	sick dr state					160	leave
31-Mar-96	23	917	AB033	sl care fam mbr					86	leave
31-Mar-96	28	905	AB033	annual					52	leave
31-Mar-96	28	910	AB033	sick no dr stat					30	leave
31-Mar-96	28	940	AB033	comp time work					29	leave
31-Mar-96	28	941	AB033	comp time taken					32	leave
31-Mar-96	29	942	AB033	TDY					36	leave
31-Mar-96				**TOTAL**					**1755**	leave
31-Mar-96	7	124	4208C	prep Glatt mix		582	109	473		meas
31-Mar-96	7	128	4208C	rbld Glatt mix		185	15	170		meas

Jobs AB033/4208C Combined

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

M83 Smoke Grenade

31-Mar-96	8	309	4208C	F&P south		2741.5	1168	1574		meas
31-Mar-96	8	611	4208C	clean-up		348		348		meas
31-Mar-96	8	614	4208C	F&P inv 100%		91	40	51		meas
31-Mar-96	15	122	AB033	prepare slugs	57463	81	19	62		meas
31-Mar-96	16	124	AB033	prepare Glatt mix	34	419.5	90	329.5		meas
31-Mar-96	16	128	AB033	rebld Glatt mix	33	235.5		235.5		meas
31-Mar-96	16	309	AB033	F&P south	53558	1746	403	1343		meas
31-Mar-96	16	611	AB033	clean up		20		20		meas
31-Mar-96	17	614	AB033	F&P inv 100%	53609	56	11	45		meas
31-Mar-96				TOTAL		6505.5	1855	4651		meas
31-Mar-96	4	721	AB033	meetings					21	ovrhd
31-Mar-96	4	754	AB033	foreman sf cte					2	ovrhd
31-Mar-96	4	765	AB033	training					10	ovrhd
31-Mar-96	4	770	AB033	clerical					130	ovrhd
31-Mar-96	5	782	AB033	dispensary					4	ovrhd
31-Mar-96	5	787	AB033	eeo activities					6	ovrhd
31-Mar-96	5	796	AB033	clean up					1145.5	ovrhd
31-Mar-96	19	704	AB033	eeo counselors					20	ovrhd
31-Mar-96	19	713	AB033	misc OH					2	ovrhd
31-Mar-96	20	721	AB033	meetings					143	ovrhd
31-Mar-96	20	733	AB033	light duty					299	ovrhd
31-Mar-96	20	765	AB033	training					20	ovrhd
31-Mar-96	20	782	AB033	dispensary					45	ovrhd
31-Mar-96	21	786	AB033	awards					12	ovrhd
31-Mar-96	21	787	AB033	eeo activities					108	ovrhd
31-Mar-96	21	793	AB033	caira/surety					4	ovrhd
31-Mar-96	21	799	AB033	comm counsl ctr					27	ovrhd
31-Mar-96	27	713	AB033	misc OH					16	ovrhd
31-Mar-96	27	721	AB033	meetings					8	ovrhd
31-Mar-96	28	782	AB033	dispensary					4	ovrhd
31-Mar-96	228	770	AB033	clerical					154.5	ovrhd
31-Mar-96				TOTAL					2181	ovrhd

Pine Bluff Arsenal

Production Division Monthly Labor Yield

Sorted by Month

Jobs AB033/4208C Combined | **M83 Smoke Grenade**

31-Mar-96	1	650	4208C	supervision					652	unmeas
31-Mar-96	1	654	4208C	admin					125	unmeas
31-Mar-96	2	661	4208C	prev maint					87	unmeas
31-Mar-96	3	650	AB033	supervision					546	unmeas
31-Mar-96	4	654	AB033	admin					89	unmeas
31-Mar-96	4	661	AB033	prev maintenanc					68	unmeas
31-Mar-96	9	656	4208C	line maint					12	unmeas
31-Mar-96	9	660	4208C	lt duty-occup					195	unmeas
31-Mar-96	9	661	4208C	lt dty-nonoccup					246	unmeas
31-Mar-96	9	694	4208C	rework flt/prod					80	unmeas
31-Mar-96	17	650	AB033	misc					10	unmeas
31-Mar-96	17	656	AB033	line maint					50	unmeas
31-Mar-96	17	660	AB033	lt duty-occup					119	unmeas
31-Mar-96	18	661	AB033	lt duty-nonoccup					64	unmeas
31-Mar-96	18	694	AB033	rework FLT/prod					45	unmeas
31-Mar-96	24	650	4208C	supervision					40	unmeas
31-Mar-96	24	654	4208C	admin					122	unmeas
31-Mar-96	24	662	4208C	engr support					157	unmeas
31-Mar-96	24	663	4208C	tech support					123	unmeas
31-Mar-96	26	650	AB033	supervision					59	unmeas
31-Mar-96	26	654	AB033	admin					126	unmeas
31-Mar-96	27	662	AB033	engr support					113	unmeas
31-Mar-96	27	663	AB033	technical support					163	unmeas
31-Mar-96				**TOTAL**					**3291**	unmeas
	MARCH TOTALS									

Jobs AB033/4208C Combined

Pine Bluff Arsenal
Production Division Monthly Labor Yield
Sorted by Month

M83 Smoke Grenade

29-Feb-96	9	835	4208C	on job training				70			down
29-Feb-96	9	845	4208C	dwntme compon				180			down
29-Feb-96	10	850	4208C	dwntm equip os				81			down
29-Feb-96	10	853	4208C	dwntm samples				19			down
29-Feb-96	10	861	4208C	dwntm inv fire				33			down
29-Feb-96	10	871	4208C	dwntm lot no ch				11			down
				TOTAL				**394**			down
29-Feb-96	8	110	4208C	prep start mix			120		120		meas
29-Feb-96	8	122	4208C	prepare slugs			117	10	107		meas
29-Feb-96	8	124	4208C	prep Glatt mix			330	50	280		meas
29-Feb-96	8	128	4208C	rebld Glatt mix			52		52		meas
29-Feb-96	8	309	4208C	F&P south			890	323	567		meas
29-Feb-96	8	611	4208C	clean-up			36		36		meas
29-Feb-96	9	614	4208C	F&P inv 100%			29	11	18		meas
				TOTAL			**1574**	**394**	**1180**		meas
29-Feb-96	1	650	4208C	supervision						299	unmeas
29-Feb-96	1	654	4208C	admin						59	unmeas
29-Feb-96	9	656	4208C	line maint						40	unmeas
29-Feb-96	9	660	4208C	lt duty-occup						60	unmeas
29-Feb-96	9	661	4208C	lt dty-nonoccup						85	unmeas
29-Feb-96	26	662	4208C	engr support						58	unmeas
				TOTAL						**601**	unmeas
	FEBRUARY TOTALS										

Pine Bluff Arsenal
Production Division Monthly Labor Yield

Jobs AB033/4208C **M83 Smoke Grenade**

Month	Reprt Page	Activity Code	Job #	Activity Description	Net Units	Actual Hours Measured	Down Hours	Net Hours Measured	Actual Hrs Unmeasd	stat
31-May-96	1	650	AB033	supervision					1386	unmeas
31-May-96	1	654	AB033	admin					147.5	unmeas
31-May-96	2	661	AB033	prev maintenanc					68.5	unmeas
31-May-96	2		AB033	**TOTAL**					**1602**	unmeas
31-May-96	2	710	AB033	admin					5.5	ovrhd
31-May-96	2	721	AB033	meetings					20	ovrhd
31-May-96	2	765	AB033	training					10	ovrhd
31-May-96	3	770	AB033	clerical					159.5	ovrhd
31-May-96	3	786	AB033	awards					9	ovrhd
31-May-96	3	792	AB033	official function					8	ovrhd
31-May-96	3	796	AB033	clean up					803	ovrhd
31-May-96	3		AB033	**TOTAL**					**1015**	ovrhd
31-May-96	4	905	AB033	annual					203	leave
31-May-96	4	910	AB033	sick no dr stat					49	leave
31-May-96	4	917	AB033	sl care fam mbr					13	leave
31-May-96	4	920	AB033	holiday lv					110	leave
31-May-96	4		AB033	**TOTAL**					**375**	leave
31-May-96	6	122	AB033	prepare slugs	12390	15	1	14		meas
31-May-96	6	124	AB033	prep Glatt mix	57	933.5	258	675.5		meas
31-May-96	6	128	AB033	Rebld Glatt mix	23	149.5		149.5		meas
31-May-96	7	246	AB033	Punch screens	77500	79		79		meas
31-May-96	7	309	AB033	F&P south	73747	4877.5	984	3893.5		meas
31-May-96	7	524	AB033	Packout	37216	317	24	293		meas
31-May-96	8	611	AB033	Cleanup	17	175		175		meas
31-May-96	8	614	AB033	F&P Inv 100% so	73747	158	27	131		meas
31-May-96	8	619	AB033	P.O. Inv 100%	37216	19	1	18		meas
31-May-96	8		AB033	**TOTAL**	**311913**	**6724**	**1295**	**5429**		meas
31-May-96	8	656	AB033	Line maint					58.5	unmeas
31-May-96	9	694	AB033	Rework					83	unmeas
31-May-96	9		AB033	**TOTAL**					**142**	unmeas

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Pine Bluff Arsenal
Production Division Monthly Labor Yield

Jobs AB033/4208C **M83 Smoke Grenade**

31-May-96	9	835	AB033	On-job training			49			down
31-May-96	9	847	AB033	Adj of equip			31			down
31-May-96	9	850	AB033	Dwntime Equip			989			down
31-May-96	10	851	AB033	Dwntime line chg			4			down
31-May-96	10	853	AB033	Dwntm samples			216			down
31-May-96	10	871	AB033	Dwntm lot no ch			6			down
31-May-96	10		AB033	**TOTAL**			**1295**			down
31-May-96	16	650	AB033	supervision					185	unmeas
31-May-96	17	654	AB033	administration					333	unmeas
31-May-96	17	661	AB033	prev maint					108	unmeas
31-May-96	17	662	AB033	engr support					276.5	unmeas
31-May-96	18	663	AB033	tech supt					397.5	unmeas
31-May-96	18		AB033	**TOTAL**					**1300**	unmeas
31-May-96	18	710	AB033	admin					4	ovrhd
31-May-96	18	721	AB033	meetings					20.5	ovrhd
31-May-96	18	765	AB033	training					2	ovrhd
31-May-96	18	770	AB033	clerical					151	ovrhd
31-May-96	19	771	AB033	timekeeping					6.5	ovrhd
31-May-96	19	786	AB033	awards					11	ovrhd
31-May-96	19	792	AB033	official function					5	ovrhd
31-May-96	19		AB033	**TOTAL**					**200**	ovrhd
31-May-96	19	905	AB033	annual					158	leave
31-May-96	20	910	AB033	sick no dr stat					52	leave
31-May-96	20	917	AB033	sl care fam member					7	leave
31-May-96	20	920	AB033	holiday lv					110	leave
31-May-96	20	933	AB033	voluntary lwop					14	leave
31-May-96	20	940	AB033	comp time work					6	leave
31-May-96	20	941	AB033	comp time taken					20	leave
31-May-96	20		AB033	**TOTAL**					**367**	leave
30-Apr-96	1	650	AB033	supervision					1403	unmeas
30-Apr-96	2	654	AB033	admin					250	unmeas
30-Apr-96	2	661	AB033	prev maintenanc					161	unmeas

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Jobs AB033/4208C **M83 Smoke Grenade**

30-Apr-96	2		AB033	**TOTAL**					**1814**	unmeas
30-Apr-96	3	713	AB033	misc overhead					8	ovrhd
30-Apr-96	3	721	AB033	meetings					9	ovrhd
30-Apr-96	3	732	AB033	post wide evacu					10	ovrhd
30-Apr-96	3	754	AB033	foreman sf cte					1	ovrhd
30-Apr-96	3	765	AB033	training					171	ovrhd
30-Apr-96	4	770	AB033	clerical					164	ovrhd
30-Apr-96	4	773	AB033	filing					8	ovrhd
30-Apr-96	4	782	AB033	dispensary					2	ovrhd
30-Apr-96	4	796	AB033	clean up					1950	ovrhd
30-Apr-96	4		AB033	**TOTAL**					**2323**	ovrhd
30-Apr-96	5	905	AB033	annual					145	leave
30-Apr-96	5	910	AB033	sick no dr stat					87	leave
30-Apr-96	5		AB033	**TOTAL**					**232**	leave
30-Apr-96	7	110	AB033	prep start mix	69	170	5	165		meas
30-Apr-96	7	122	AB033	prepare slugs	83930	112	1	111		meas
30-Apr-96	8	124	AB033	prep Glatt mix	64	1084	445	639		meas
30-Apr-96	8	128	AB033	rebld Glatt mix	46	264		264		meas
30-Apr-96	9	246	AB033	punch screens	86500	118		118		meas
30-Apr-96	9	309	AB033	F&P south	7626	4109	962	3147		meas
30-Apr-96	9	524	AB033	Packout	36720	342	85	257		meas
30-Apr-96	10	611	AB033	clean-up	37	362		362		meas
30-Apr-96	10	614	AB033	F&P inven 100%	7626	155	27	128		meas
30-Apr-96	10	619	AB033	P.O. inven100%	36720	29	4	25		meas
30-Apr-96	10		AB033	**TOTAL**	**259338**	**6745**	**1529**	**5216**		meas
30-Apr-96	11	656	AB033	line maint					70.5	unmeas
30-Apr-96	11	660	AB033	lt duty-occup					70	unmeas
30-Apr-96	11	661	AB033	lt dty-nonoccup					20	unmeas
30-Apr-96	11	692	AB033	screen for vend					27	unmeas
30-Apr-96	11	694	AB033	rework FLT/prod					125	unmeas
30-Apr-96	11		AB033	**TOTAL**					**313**	unmeas
30-Apr-96	12	835	AB033	on job training			298			down

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Jobs AB033/4208C

M83 Smoke Grenade

30-Apr-96	12	846	AB033	defect compon			6			down
30-Apr-96	12	847	AB033	adj of equip			87			down
30-Apr-96	13	850	AB033	dwntm equip os			799			down
30-Apr-96	13	853	AB033	dwntm samples			213			down
30-Apr-96	14	861	AB033	dwntm inv fire			106			down
30-Apr-96	14	865	AB033	dwntm weather			4			down
30-Apr-96	14	871	AB033	dwntm lot no ch			16			down
30-Apr-96	14		AB033	**TOTAL**			**1529**			down
30-Apr-96	14	704	AB033	eeo counselors					40	ovrhd
30-Apr-96	14	713	AB033	misc OH					2	ovrhd
30-Apr-96	14	721	AB033	meetings					62	ovrhd
30-Apr-96	14	732	AB033	post wide evacu					52	ovrhd
30-Apr-96	15	733	AB033	light duty					313	ovrhd
30-Apr-96	15	765	AB033	training					300	ovrhd
30-Apr-96	15	782	AB033	dispensary					43.5	ovrhd
30-Apr-96	16	787	AB033	eeo activities					4	ovrhd
30-Apr-96	16	799	AB033	comm counsl ctr					2	ovrhd
30-Apr-96	16		AB033	**TOTAL**					**819**	ovrhd
30-Apr-96	16	905	AB033	annual					930	leave
30-Apr-96	16	910	AB033	sick no dr stat					457	leave
30-Apr-96	17	912	AB033	sick dr stat					180	leave
30-Apr-96	18	917	AB033	sl care fam mbr					40	leave
30-Apr-96	18	922	AB033	court lv					20	leave
30-Apr-96	18	925	AB033	time off award					40	leave
30-Apr-96	18		AB033	**TOTAL**					**1667**	leave
30-Apr-96	19	650	AB033	supervision					125	unmeas
30-Apr-96	19	654	AB033	administration					342.5	unmeas
30-Apr-96	20	662	AB033	engr support					367.5	unmeas
30-Apr-96	21	663	AB033	technical support					342	unmeas
30-Apr-96	21		AB033	**TOTAL**					**1177**	unmeas
30-Apr-96	21	721	AB033	meetings					12	ovrhd
30-Apr-96	21	732	AB033	post wide evacu					7	ovrhd

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Jobs AB033/4208C

M83 Smoke Grenade

30-Apr-96	21	765	AB033	training					88	ovrhd
30-Apr-96	22	770	AB033	clerical					132	ovrhd
30-Apr-96	22		AB033	**TOTAL**					**239**	ovrhd
30-Apr-96	22	905	AB033	annual					121	leave
30-Apr-96	22	910	AB033	sick no dr stat					57	leave
30-Apr-96	22	917	AB033	sl care fam mbr					5	leave
30-Apr-96	23	922	AB033	court lv					24	leave
30-Apr-96	23	933	AB033	voluntary lwop					5	leave
30-Apr-96	23	940	AB033	comp time work					31	leave
30-Apr-96	23	941	AB033	comp time taken					32	leave
30-Apr-96	23	942	AB033	TDY					15	leave
30-Apr-96	23		AB033	**TOTAL**					**290**	leave
31-Mar-96	3	650	AB033	supervision					546	unmeas
31-Mar-96	4	654	AB033	admin					89	unmeas
31-Mar-96	4	661	AB033	prev maintenanc					68	unmeas
31-Mar-96	4		AB033	**TOTAL**					**703**	unmeas
31-Mar-96	4	721	AB033	meetings					21	ovrhd
31-Mar-96	4	754	AB033	foreman sf cte					2	ovrhd
31-Mar-96	4	765	AB033	training					10	ovrhd
31-Mar-96	4	770	AB033	clerical					130	ovrhd
31-Mar-96	5	782	AB033	dispensary					4	ovrhd
31-Mar-96	5	787	AB033	eeo activities					6	ovrhd
31-Mar-96	5	796	AB033	clean up					1145.5	ovrhd
31-Mar-96	5		AB033	**TOTAL**					**1319**	ovrhd
31-Mar-96	5	905	AB033	annual					128	leave
31-Mar-96	6	910	AB033	sick no dr stat					82	leave
31-Mar-96	6	924	AB033	continue of pay					10	leave
31-Mar-96	6	933	AB033	voluntary lwop					2	leave
31-Mar-96	6		AB033	**TOTAL**					**222**	leave
31-Mar-96	15	122	AB033	prepare slugs	57463	81	19	62		meas
31-Mar-96	16	124	AB033	prepare Glatt mix	34	419.5	90	329.5		meas
31-Mar-96	16	128	AB033	rebld Glatt mix	33	235.5		235.5		meas

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Jobs AB033/4208C **M83 Smoke Grenade**

31-Mar-96	16	309	AB033	F&P south	53558	1746	403	1343		meas
31-Mar-96	16	611	AB033	clean up		20		20		meas
31-Mar-96	17	614	AB033	F&P inv 100%	53609	56	11	45		meas
31-Mar-96	17		AB033	**TOTAL**	**164697**	**2558**	**523**	**2035**		meas
31-Mar-96	17	650	AB033	misc					10	unmeas
31-Mar-96	17	656	AB033	line maint					50	unmeas
31-Mar-96	17	660	AB033	lt duty-occup					119	unmeas
31-Mar-96	18	661	AB033	lt duty-nonoccup					64	unmeas
31-Mar-96	18	694	AB033	rework FLT/prod					45	unmeas
31-Mar-96	18		AB033	**TOTAL**					**288**	unmeas
31-Mar-96	18	835	AB033	on job training			90			down
31-Mar-96	18	845	AB033	dwntm compon			111			down
31-Mar-96	18	847	AB033	adj of equip			19			down
31-Mar-96	18	850	AB033	dwntm equip os			180			down
31-Mar-96	19	851	AB033	dwntm line chg			3			down
31-Mar-96	19	853	AB033	dwntm samples			109			down
31-Mar-96	19	871	AB033	dwntm lot no ch			11			down
31-Mar-96	19		AB033	**TOTAL**			**523**			down
31-Mar-96	19	704	AB033	eeo counselors					20	ovrhd
31-Mar-96	19	713	AB033	misc OH					2	ovrhd
31-Mar-96	20	721	AB033	meetings					143	ovrhd
31-Mar-96	20	733	AB033	light duty					299	ovrhd
31-Mar-96	20	765	AB033	training					20	ovrhd
31-Mar-96	20	782	AB033	dispensary					45	ovrhd
31-Mar-96	21	786	AB033	awards					12	ovrhd
31-Mar-96	21	787	AB033	eeo activities					108	ovrhd
31-Mar-96	21	793	AB033	caira/surety					4	ovrhd
31-Mar-96	21	799	AB033	comm counsl ctr					27	ovrhd
31-Mar-96	21		AB033	**TOTAL**					**680**	ovrhd
31-Mar-96	21	905	AB033	annual					606	leave
31-Mar-96	22	910	AB033	sick no dr stat					502	leave
31-Mar-96	22	912	AB033	sick dr state					160	leave

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Jobs AB033/4208C **M83 Smoke Grenade**

31-Mar-96	23	917	AB033	sl care fam mbr					86	leave
31-Mar-96	23		AB033	**TOTAL**					**1354**	leave
31-Mar-96	26	650	AB033	supervision					59	unmeas
31-Mar-96	26	654	AB033	admin					126	unmeas
31-Mar-96	27	662	AB033	engr support					113	unmeas
31-Mar-96	27	663	AB033	technical support					163	unmeas
31-Mar-96	27		AB033	**TOTAL**					**461**	unmeas
31-Mar-96	27	713	AB033	misc OH					16	ovrhd
31-Mar-96	27	721	AB033	meetings					8	ovrhd
31-Mar-96	228	770	AB033	clerical					154.5	ovrhd
31-Mar-96	28	782	AB033	dispensary					4	ovrhd
31-Mar-96	28		AB033	**TOTAL**					**183**	ovrhd
31-Mar-96	28	905	AB033	annual					52	leave
31-Mar-96	28	910	AB033	sick no dr stat					30	leave
31-Mar-96	28	940	AB033	comp time work					29	leave
31-Mar-96	28	941	AB033	comp time taken					32	leave
31-Mar-96	29	942	AB033	TDY					36	leave
31-Mar-96	29		AB033	**TOTAL**					**179**	leave

Month	RepRt Page	Activity Code	Job #	Activity Description	Net Units	Actual Hours Measured	Down Hours	Net Hours Measured	Actual Hrs Unmeasd	stat
31-Mar-96	1	650	4208C	supervision					652	unmeas
31-Mar-96	1	654	4208C	admin					125	unmeas
31-Mar-96	2	661	4208C	prev maint					87	unmeas
31-Mar-96	2		4208C	**TOTAL**					**864**	unmeas
31-Mar-96	7	124	4208C	prep Glatt mix		582	109	473		meas
31-Mar-96	7	128	4208C	rbld Glatt mix		185	15	170		meas
31-Mar-96	8	309	4208C	F&P south		2741.5	1168	1574		meas
31-Mar-96	8	611	4208C	clean-up		348		348		meas
31-Mar-96	8	614	4208C	F&P inv 100%		91	40	51		meas
31-Mar-96	8		4208C	**TOTAL**		**3947.5**	**1332**	**2615.5**		meas
31-Mar-96	9	656	4208C	line maint					12	unmeas

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Jobs AB033/4208C **M83 Smoke Grenade**

31-Mar-96	9	660	4208C	lt duty-occup					195	unmeas
31-Mar-96	9	661	4208C	lt dty-nonoccup					246	unmeas
31-Mar-96	9	694	4208C	rework flt/prod					80	unmeas
31-Mar-96	9		4208C	**TOTAL**					**533**	unmeas
31-Mar-96	10	835	4208C	on job trng			118			down
31-Mar-96	10	845	4208C	dwntme compon			14			down
31-Mar-96	10	847	4208C	adj of equip			45			down
31-Mar-96	10	850	4208C	dwntm equip os			970			down
31-Mar-96	11	853	4208C	dwntm samples			91			down
31-Mar-96	11	865	4208C	dwntm weather			65			down
31-Mar-96	11	871	4208C	dwntm lot no ch			29			down
31-Mar-96	11		4208C	**TOTAL**			**1332**			down
31-Mar-96	24	650	4208C	supervision					40	unmeas
31-Mar-96	24	654	4208C	admin					122	unmeas
31-Mar-96	24	662	4208C	engr support					157	unmeas
31-Mar-96	24	663	4208C	tech support					123	unmeas
31-Mar-96	24		4208C	**TOTAL**					**442**	unmeas
29-Feb-96	1	650	4208C	supervision					299	unmeas
29-Feb-96	1	654	4208C	admin					59	unmeas
29-Feb-96	1		4208C	**TOTAL**					**358**	unmeas
29-Feb-96	8	110	4208C	prep start mix		120		120		meas
29-Feb-96	8	122	4208C	prepare slugs		117	10	107		meas
29-Feb-96	8	124	4208C	prep Glatt mix		330	50	280		meas
29-Feb-96	8	128	4208C	rebld Glatt mix		52		52		meas
29-Feb-96	8	309	4208C	F&P south		890	323	567		meas
29-Feb-96	8	611	4208C	clean-up		36		36		meas
29-Feb-96	9	614	4208C	F&P inv 100%		29	11	18		meas
29-Feb-96	9		4208C	**TOTAL**		**1574**	**394**	**1180**		meas
29-Feb-96	9	656	4208C	line maint					40	unmeas
29-Feb-96	9	660	4208C	lt duty-occup					60	unmeas
29-Feb-96	9	661	4208C	lt dty-nonoccup					85	unmeas
29-Feb-96	9		4208C	**TOTAL**					**185**	unmeas

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29-Feb-96	9	835	4208C	on job training			70			down
29-Feb-96	9	845	4208C	dwntme compon			180			down
29-Feb-96	10	850	4208C	dwntm equip os			81			down
29-Feb-96	10	853	4208C	dwntm samples			19			down
29-Feb-96	10	861	4208C	dwntm inv fire			33			down
29-Feb-96	10	871	4208C	dwntm lot no ch			11			down
29-Feb-96	10		4208C	**TOTAL**			**394**			down
29-Feb-96	26	662	4208C	engr support					58	unmeas
29-Feb-96	26		4208C	**TOTAL**					**58**	unmeas

Appendix B: Review of Level I Audit on TA Smoke Grenade Process

A Level I audit was conducted on the TA smoke mix, grenade fill and press, and load and packout lines situated, respectively, in Buildings 32-620, 33-530, and 33-570. Those involved in the Level I audit were PBA technical personnel with knowledge of process issues, business and finance, quality issues, environmental, energy performance, and maintenance associated with the TA smoke grenade process. In addition to the PBA technical personnel, USACERL researchers, a team leader from IOC, and contractors from ETSI Consulting, Inc. and Stanley Consultants, Inc. also assisted in the Level I audit. The PBA technical staff formed an integral part of the audit team because they brought to it first-hand experience of the TA smoke grenade process. A Level I audit uses "guess" economics and no measurements. However, the persons making the "guesses" are those who are intimately associated with the targeted process.

Establishing Potential Dollar Value

The Resource Management Office at PBA as of 8 July 1996 reported FY97 revenue for all of PBA. Data from PBA budget for 1997 (Table B1) were reviewed for Level I analyses. These data were compared with other data recommended by the team. The breakdown of revenue for manufacturing is shown in Table A2.

Brainstorming for Level I Audit

In creating the new process, capacity, environmental, and energy issues were considered separately. In each of the three areas, the participants used Nominal Group Brainstorming techniques. The process changes were recorded, subsequently participants voted on the concepts, and top concepts were selected. Table B3 shows the results of the brainstorming conducted during the Level I audit.

Table B1. Pine Bluff Arsenal's FY97 revenue projections.

Description of Total FY97 Revenue for:	Direct Hours (D.H.)	Labor $	Material & Equip $	Services	Applied Overhead	Total Revenue	per cent
Manufacturing	579,936	14,022,990	17,561,895	1,967,636	26,178,619	59,731,140	61.2
Demilitarize	66,830	1,651,312	129,776	118,435	2,578,479	4,478,002	4.6
Other	335,611	7,826,758	1,797,069	1,896,757	21,906,470	33,427,054	34.2
Total	982,377	23,501,060	19,488,740	3,982,828	50,663,568	97,636,196	100
Percent		24.0	20.00	4.1	51.9	100	

Weakness Analysis: Capacity Bottlenecks in the Fill and Press

Weakness analyses were conducted from the following perspectives: readiness (startup time, capacity), reliability (power outages), quality (correct measurements, corrective actions), safety/health, environment, utilities consumption, labor requirements, and cost improvement. Three bottlenecks were identified in the fill and press process. The bottlenecks were prioritized according to the amount of downtime each caused. The fast track conveyor (steps 10, 11, 12, 13, and 14) caused 40 percent of the downtime of the fill and press process. The installation and seal (step 15) caused 7 percent of the downtime and the most rejects accumulated at this station. The Consolidate press (Step 5) caused 5 percent of the downtime.

The weakness analysis was conducted from the following perspectives: readiness (startup time, capacity), reliability (power outages), quality (correct measurements, corrective actions), safety/health, environment, utilities consumption, labor requirements, and cost. Tables B6 and B7 show the results of the weakness analyses.

Table B2. Identifying the manufacturing cost structure.

Item Cost		
Labor Material & Equipment Services Applied Overhead		$14,022,990 $17,561,895 $1,967,636 $26,178,619
By dividing	Labor Cost Total Rev	$14,022,990 $59,731,140
	= 23 percent	$59,731,140 $579,936
By dividing	Total Rev. Mftg D.H.	
	= $102.99/Direct Labor Hours	

Table B3. Brainstorming concepts for capacity optimization.

Concepts	Votes
1.	
2. Combine the 2 pressing operations (3 & 5)into one	8
3. Consolidate steps 11,12, 13, 15	5
4. Redesign stops for motion detection	7
5. Update PLC to do job it is suppose to do	9*
6. Replace the conveyor with a belt	15*
7. Convert to manual operation short term	3#
8. Install a good dust collector, or use the one on the north side of building	13*
9. Provide access to both sides of conveyor at all steps	0*
10. Do #5 using existing frame	12*
11. Automate down stream and use manpower where needed	10*
12. Fix machine alignment	1#

Concepts	Votes
13. Do #9 but ensure a method of how to "off line" for positive location	6
14. Do not operate the pretreatment for waste water plant	0^
15. Install a failure indicator	10#*
16. Add two more maintenance people/shift	0
17. Change out the can loader	3
18. Have a back up can sealer and consolidation press	0
19. Replace old automatic can sealer with newer one	3
20. Short term use existing manual can sealers (2 - 4)	0^
21. Re-arrange whole layout	15
22. Readiness deserves redundancy	3*
23. Install pollution control equipment on line so quality check can be done on site 0	
24. Do #20 by layout equipment in proper sequence by using all 9 cubicles	6
25. Do #2 by preassembling # 11, 12, and 13	9#*
26. Provide dust proofing for bearings	2
27. Utilize existing data collecting system	4^
28. Convert to plastic grenade body and lid	11*
29. Combine fill and press operation with load and pack to eliminate (steps 29 -31)	1
30. Modify north side line to handle TA units so both can operate	5
31. t + 40 percent more output	
32. Move the line closer to Glatt	4
33. Do #1 and combine #s3, 5, 8	1
34. Do suggestion 28 and eliminate consolidation press step #5	9*
35. Redesign the pallet and stop mechanism if we must stick with conveyor	0
36. Perform PM at end of each of shift and at lunch	10*#
37. Totally enclose painting operation	0
38. Prepare /reverse/modify the lid feed system for the sealer	12*
39. Convert to single slug on the Glatt line to eliminate steps 3,5,6,7,8	5
40. Lease an air compressor	2#
41. Do # 14 by showing the block diagram on the PLC	0
42. Combine step 23 and 24 (twist and torque)	0#
43. Eliminate screen starter cup and cardboard disc by going to an alternate ignition system	5
44. Don't repaint it green or don't repaint	6
45. Eliminate dirty compressed air by installing an oil, dirt, moist system filter	5#
46. Put a dust jacket over the 1st press machine (step #5) to minimize dust	0
47. Use alternative clean up method	0#
48. Combine 2-6 into one operation by using Stokes press	9*
49. Use extra can sealers in cubicle 7 and 8	4
50. Redesign the cardboard containers so fuse guard is not needed	0
51. Go to a nonsolvent base paint	2
52. Optimize cycle time of consolidation press by removing delay time	15^*
53. Work environment should be improved to raise motivate	0
54. Use pre-painted cans	0
55. Reduce applied overhead by eliminating internal reviews and half of management analysis staff	0
56. Move air compressor from the 34640 to 33-530	9*
57. Fix compress problem at central location with good maintenance	8
58. Skid mount all equipment	4
59. Separate interlock control on work station at the front of line	1#
60. Redesign the fuse guard so the container is not needed	0
61. Convert the paint booth water curtain to dry filters	0
62. Design stencil machine to combine #21 and 22	8
63. Do 57 for air compressor	2
64. Modify line to produce multiple size canisters	8
65. Redesign the molds for the consolidation press	2
66. Tighten the controls (Quality Assurance) especially oversized cans, not like drawings	16^*

Concepts	Votes
67. Re-evaluate critical dimensions on all parts being automatically installed	6
68. Replace Glatt Mixer with in line “Static” or “Motion Less” for more uniformity with simplicity	3
69. Optimize maintenance support Organization/Resources/Other	13#*
70. Optimize training to support goals	6#
71. Form formal productivity team.	6^
KEY: # = Major Funding; ^ = No Cost; * = Low Cost	

Table B4. Brainstorming concepts for energy optimization.

Concepts	Votes
1. Cycle chiller units with work/holiday requirements	7
2. Investigate use of a fuel cell	0#
3. Convert Glatt to gravity tumbler to eliminate air	0
4. Optimize steam pressure lower to 75 psig from 125 psig	23*
5. Decentralize steam system to discontinue use of boilers in summer or all year long. (Condense lines to supply gas to package boilers)	23*
6. Increase PVA concentration in water mix to reduce heating/drying	8*
7. Reduce number of moving parts to save logistical energy	0
8. Recover waste heat from incinerator	0
9. Use air recirculation to reduce chiller cost at fill and press	5
10. Eliminate/decommission unused steam lines (rule of thumb =10K/1000 liner feet)	19*#
11. Do a leak survey for air/steam	8*#
12. Insulate buildings to save steam and cooling load	1
13. Use recent motor efficiency study to replace motor underloading	2
14. Energy efficient lighting	11#*
15. Group relamp vs spot replacement	4*#
16. Investigate VSD for chiller	0
17. Provide means to turn off sub light	0
18. Use alternate dehumidification (desiccant drying-silica gel)	3
19. Improve power factor	0
20. Install EMS to reduce demand . A 600 avoided demand out of 6000 kW will save 600x 13.73 x 8 month/year.	10*
21. Repair/replace failed steam traps	0#
22. Optimize air mixing/drying/cooling cycle time. in Glatt	7#
23. Decentralize compressed air system	8*
24. Better method to heat PVA without steam	0#
25. Replace mixer with in line mixer	4
26. Initiate 5 member energy team	10*^
27. Insulate steam pipes	0
28. Consolidate ductwork in air system	0
29. Convert v-belts to 300 kW on V belts COG °belts	5#
30. VFD for boiler house FD/ID fans	1
31. Meter industrial energy (Air/steam/Elec)	5
32. Fix air dryer to eliminate water in air lines	3
33. Determine site wide building heating/cooling needs and decommissions	2#
KEY:# = Major Funding; ^ = No Cost; * = Low Cost	

Table B5. Brainstorming concepts for environmental optimization.

Concepts	Votes
1. Totally enclose paint operation	3#
2. Evaluate feasibility of permanent reject grenade demanufacture	15^*
3. Go to nonsolvent based paint	10*
4. Improve dust collection	13*
5. Determine the need to pretreat waste water	15*# ^
6. Convert the water curtain to dry filters	4
7. Develop a dry clean-up method	6
8. Recycle water where possible	10*
9. Reduce incinerator water load by using waste water to cool	8
10. Enclose weigh are at Glatt to control dust emissions	3
11. After treatment of wastewater, recycle to process	7
12. Vacuum up dust	10*
13. Develop a proactive leak survey on water	6
14. Evaluate less expensive stencil inks	0
15. Solid waste reduction via source	0
16. Get TA in 55-gal drums	15*
17. Recycle water at incinerator	1
18. Identify sludge dewatering technology	3
19. Optimize SOP for TA washdown	0#
20. Provide APC for smoke from QC tests	8
21. Organize and consolidate stations	1
22. Improve ventilation in paint area	3
23. Close pretreatment plant	6^
24. Tear up buildings to make work smoother	0
25. Initiate five-member environmental teams	16^*
26. Use spring loaded low volume nozzles for cleanup	8#
27. Use station specific vacuum clean system	0
28. Meter industrial water and charge accordingly	4
29. Convert to non CFCs on a cost effective timetable	6
(cost of problem @ $1000/Ton Assume 1500/ton $1.5M to replace)	
KEY: # = Major Funding; ^ = No Cost; * = Low Cost	

Table B6. Where-why analysis (capacity - fast track conveyor).

Where	Why
1. Pallet (a, b, c, d, e, f, h)	a. Poor design
2. 2 Elevators (a, b, c, d, e, f, g, h) (steps #10, #14)	b. Too automated for dusty environment
3. Shaft bearings (c)	c. Dust into bearings
4. Mech. stops (c, f, g, i)	d. Dust into cylinders
5. Queue Station (c, f, g, i)	e. Too complex for required job
6. Pick & Place (b, h, f, a, l) (step #10)	f. Not maintenance friendly
	g. No diagnostics between stations
	h. Bad alignment problem
	I. No visible indication of failure
	j. Poor QA on incoming parts
Note: The Where column indicates the location of the problem, and the corresponding cause(s) for the problem are shown in parentheses. The Why column includes the cause of the problems.	

Table B7. Where-why analysis (environmental issues).

Where	Why
A. Glatt	
1. Waste water (a)	a. Wash down
2. Air emissions(b, h)	b. Particulates
3. Solid waste (a, e)	c. Indoor air quality
4. Dirty indoor air (b, d)	d. Dust health probleme. Bad batch
B. Fill & Press	f. Painting
1. Waste water (a, f)	g. Rejects
2. Air emissions (f)	h. Excess mix
3. Solid waste (g, h)	i. Stencil
C. LAP	
2. Air emissions (I)	
3. Solid waste (I)	
Note: The Where column indicates the location of the problem, and the corresponding cause(s) for the problem are shown in parentheses. The Why column includes the cause of the problems.	

Appendix C: Data-Gap Analysis

Capacity: General Questions

- Are the estimates of percent increase in productivity to be taken as accurate? (It would be difficult if not impossible to develop more accurate estimates based on the data available.)
- From the monthly scrap/rework data provided by PBA (these reports contain the code "SMCPB-MOQ" in the upper left corner of each monthly report), it seems that scrap and rework figures vary greatly each month? What is this due to? What should be used as a "baseline" (average) of scrap/rework costs/quantities?
- Being a government facility, the capacity of PBA is "capped," that is, PBA produces only what the government orders. There is no market (and hence no revenue) for any more units produced due to increased efficiency. Is it acceptable to interpret "x percent increase in efficiency" to be synonymous with "x percent decrease in the number of personnel hours (used to produce the government-regulated quantity of units demanded."

#6 Go Manual

None

#14 Install Failure Indicator Light

- Electrical and lighting drawings, electrical panel locations, and panel schedules of the fill and press line area, showing where existing lighting and 120-volt outlets are located, and where one can find power for the new alarm lights (e.g., pull off existing circuits or run new circuits).
- Idea of how many alarm lights should be installed to warn the operators along the entire assembly line.

#39 Lease Air Compressor

- Plan of the existing compressed air system, showing pipe layout and size in the F+P area.
- What is the required air pressure in the fill and press area?
- Electrical drawings of the fill and press area (need to see if enough power exists to run electrical compressor).

- Is PBA subject to any special requirements regarding emissions? (USACERL also must analyze diesel-powered air compressor).

#7 Install Good Dust Collector System

- Need plan layout of fill and press area, with the dusty areas (that have to be collected) marked.
- Need HVAC plans, showing layout of any ducting that brings in outside air and/or distributes air around the fill and press area.
- Need electrical drawings to see where power can be obtained to run dust collection.
- Need to take into account current condition and capabilities of existing air pollution control equipment, any planned production changes, new equipment needs, and change in the process such as burning alternate fuels.

#66 "Re-Evaluate Critical Dimensions on All Parts Automatically Installed

- From the monthly scrap/rework data provided by PBA (the code "SMCPB-MOQ" is in the upper left corner of each monthly report), which of the following references are to smoke grenades: "canister," "cartridge," or "grenade" (this study assumed only "grenade").
- From the monthly scrap/rework data provided by PBA, how is the "Net Value" column calculated?
- Which of the smoke grenade parts are automatically installed?

#24 Preassemble Cup, Slug, and Starter

- Need to know the amount of time taken at present to perform the tasks of inserting the cup, slug, and starter.
- Need to know the anticipated time it would take to preassemble the cup, slug, and starter (so that the time used—if any—in preassembling can be calculated).
- Will any additional "off line" assembly line area or equipment be required to preassemble the cup, slug and starter? Or can this be done with the present facilities (i.e., can this change in production line be made with no cost)?

#41 Combine Twist and Torque

- This can apparently be done by simply eliminating one position on the line. Is this in fact the case? If one position were eliminated, could the present rate of production be maintained? Or will the production process slow down? If so, by how much? ("Employees' Health and Safety" in Chapter 4)

#58 Separate Interlock Controls

- Need control drawings, showing present control system.

- Need mechanical/electrical drawings of the conveyor belt (to know how to integrate new controls).

#68 and #69 Optimize Maintenance Support

- This study assumes 4 work-weeks of training will be required to train floaters to perform basic mechanical tasks, and that this training will be "purchased" paying for 4 work-weeks of time from a central shop mechanic (at the fully burdened rate of $130/hour). Are these assumptions accurate?

#37 Repair or Modify Lid System for Sealer

- What repairs are required? What modifications?
- Are there drawings, or at least a description, of the lid sealer system (so that the cost of repairs/modifications can be estimated)?

#5 and #9 Replace Fast Conveyor

- Is there some sort of scaled drawing of the fast conveyor? (Its width, length and type of conveyor are needed to estimate cost of any modifications to it.)
- Apparently, the belt is already bought. Are there any other purchases that must be made to go along with the belt?
- Is there an estimate of the amount of time required to replace belt? Will this be done with in-house staff or will it be contracted out?

#10 Automate Twist and Torque

- Need scaled mechanical drawings of this section of the line (to come up with a cost estimate of automating the process).
- What is the torque required (foot-lb)?

Environmental: General Questions

Which of the less-than-optimal environmental situations can potentially generate fines?

#1 Totally Enclose Paint Manufacture

- Does paint operation run during all hours that the assembly line operates?
- Amount of paint that is sprayed per hour (gallons) while paint booth operates? (Need to know this so that some idea of how much paint is becoming airborne can be developed.)
- Need plans showing HVAC layout, so possible exhaust system can be investigated.

#2 Evaluate feasibility of permanent reject grenade demanufacture

- What process would be used for permanent reject grenade demanufacture?
- How will doing of permanent reject grenade demanufacture alleviate environmental problems?
- Will PBA do permanent reject grenade demanufacture on site or will the rejects be shipped off site and done by contract?

#3 Go to Nonsolvent Based Paint

- What kind of paint is used now?
- Is it only used in the paint area?

#4 Improve Dust Collection

- Need plan layout of fill and press area, with the dusty areas (that have to be collected) marked.
- Need HVAC plans, showing layout of any ducting that brings in outside air and/or distributes air around the fill and press area.
- Need electrical drawings to see where to obtain power to run dust collection fans

#5 Determine the Need To Pretreat Wastewater

- What is done with wastewater now? Is waste water presently transported off site and PBA has to pay some kind of dumping fee? If so, how much is the fee? Or is waste water dumped into sanitary sewer?
- How much waste water is generated each hour of production? (Or per annum, whatever figures are available.)
- What are the types of contaminants in the waste water? What is their concentration?

#6 Convert the water curtain to dry filters

- Is water curtain operated every hour that fill and press operates?
- What is the flow rate of water per hour of water curtain operation?
- We assume dry filters would be part of some kind of air exhaust system. Is this correct? If so, then we need: (1) HVAC plans, showing layout of any ducting that brings in outside air and/or distributes air around the fill and press area, (2) electrical drawings to see where we can get power to run dust collection fans

#7 Develop a Dry Clean-Up Method

- What is used now for clean-up, the water spray?

#8 Recycle water where possible

- Where is water used? What is the cost/impact of recycle?

#11 After Treatment of Wastewater, Recycle To Process

- Need schematic flow diagram (similar to an electrical one-line drawing) showing where and how much water is used in the entire process?
- At what points in the process can less-than-clean water be used?

#10 Enclose weighing at the Glatt to control dust emissions

- Consider simply building an unventilated booth around the area, instead of ventilating the area.

#12 Vacuum up dust

- Is there any data quantifying the types of breakdowns that have occurred over time? (Attempt to draw some sort of correlation between dusty environment and bearing failure.)

#13 Develop a proactive leak survey on water

- Any idea of how many man-hours/week (or month or year) this would take?
- If successfully undertaken, does PBA have any idea of how much water they would save per year by finding leaks early instead of waiting for them to become bad leaks?

#14 Evaluate Less Expensive Stencil Inks

- What is cost of stencil inks presently used? Is there any estimate/data showing how much stencil ink is used per year?
- Assume the major performance criteria for the new inks would be: correct color and durability (i.e., they would not wash off grenades or flake off grenades in wet or hot environments).

#16 Get TA in 55-gal drums

- What would be the extra cost (if any) in doing this?

#17 Recycle Water at Incinerator

- Need schematic flow diagram (similar to an electrical one-line drawing) showing where and how much water is used in the entire process?

#18 Identify Sludge dewatering Technology

- Need schematic flow diagram (similar to an electrical one-line drawing) showing where and how much water is used in the entire process?
- What are the contaminants in the sludge?

#19 Optimize SOP for TA Washdown

- How is washdown operated now?
- What are the negative environmental effects of present TA washdown?

#20 Provide Air Pollution Control for Smoke From QC tests

- Explain this more fully

#24 Close Pretreatment Plant

- A schematic flow diagram (similar to an electrical one-line drawing) showing where and how much water is used in the entire process is needed.

#26 Initiate Environmental Team.

- How many work-hours/year would this take?
- What are the present environmental costs at PBA?

Energy Concepts

#4 Reduce Steam Pressure From 125 to 75 psig

- A plan layout of steam piping inside steam plant(s) and site piping outside plants is needed.
- Nameplate data from steam boilers are needed.

#6 Increase PVA concentration

- Any data showing how much natural gas/fuel oil was used for steam production and how much steam was produced are needed.

#26 Initiate energy team

- Full time team or part time team?

#14 Energy efficient lighting

- Some means of arriving at number of lighting fixtures and type of each fixture is needed.

#10 Decommission unused steam lines

- (None)

#5 Decentralize steam system

- Scaled site plans showing steam line locations and sizes are needed.

#23 Improve compressed air system

- Need scaled plans showing entire layout of compressed air system, as well as nameplate data on all compressors now in use.

#15 Site group relamp versus spot relamp

- Some means of arriving at number of lighting fixtures and type of each fixture is needed. (The best way is plans.) See #14 above.

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